

APPENDIX A

FY 2004 Accounting and Preliminary FY 2005 Budget Planning (prior to final allocation)

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| | | | | | | | | | | | | | | | |
|-------------------------------|--------------|-------|--------|-------|-------|-------|-------|-------|-------|----------|-------|-----------|-------|-------|-------|
| Climate Observation Program | | | | | | | | | | | | | | | |
| Budget (\$K) | | | | | | | | | | | | | | | |
| FY 04 Actual; FY 05 Planned | | | | | | | | | | | | | | | |
| Network | System Total | | | C&GC | | CCRI | | COSP | | CCRI CO2 | | ENSO/PACS | | Other | |
| | FY 04 | FY 05 | Change | FY 04 | FY 05 | FY 04 | FY 05 | FY 04 | FY 05 | FY 04 | FY 05 | FY 04 | FY 05 | FY 04 | FY 05 |
| Tide Gauges | 970 | 1345 | 375 | 0 | 275 | 320 | 921 | | | | | 650 | 0 | 0 | 149 |
| Surface Drifting Buoys | 2769 | 3406 | 637 | 627 | 386 | 1382 | 2324 | | | | | 760 | 696 | | |
| Ships of Opportunity | 2487 | 2990 | 503 | 306 | 788 | 1184 | 885 | | | | | 530 | 1317 | 467 | 0 |
| Tropical Moored Buoys | 3625 | 4135 | 510 | 600 | 0 | 0 | 510 | 450 | 450 | | | 2575 | 3175 | | |
| Argo Floats | 273 | 275 | 2 | 273 | 275 | | | | | | | | | | |
| Ocean Reference Stations | 2819 | 3319 | 500 | 0 | 425 | 2282 | 2445 | | | | | 190 | 377 | 347 | 72 |
| Arctic Ice Buoys | 0 | 60 | 60 | | | | | | | | | | | 0 | 60 |
| Ocean Carbon Networks | 2875 | 3525 | 650 | 0 | 77 | 0 | 154 | 1616 | 1873 | 1259 | 1244 | 0 | 135 | 0 | 42 |
| SURFRAD | 210 | 0 | -210 | 105 | 0 | | | | | | | | | 105 | 0 |
| Rain Gauges | 179 | 184 | 5 | 149 | 184 | | | | | | | | | 30 | 0 |
| Dedicated Ships | 523 | 80 | -443 | 523 | 80 | | | | | | | | | | |
| Service Argos Data Processing | 1525 | 1075 | -450 | 235 | 125 | 626 | 825 | | | | | 664 | 0 | 0 | 125 |
| Data & Assimilation | 369 | 443 | 74 | 369 | 343 | 0 | 100 | | | | | | | | |
| Analysis & System Evaluation | 658 | 1629 | 971 | 358 | 815 | 0 | 514 | 0 | 300 | | | 300 | 0 | | |
| Program Management | 684 | 960 | 276 | 629 | 960 | 30 | 0 | | | | | 25 | 0 | | |
| Overhead | 826 | 152 | -674 | 826 | 152 | | | | | | | | | | |
| Total | 20792 | 23578 | 2786 | 5000 | 4885 | 5824 | 8678 | 2066 | 2623 | 1259 | 1244 | 5694 | 5700 | 949 | 448 |

APPENDIX B

Program Plan for Building a Sustained Ocean Observing System for Climate

Michael Johnson
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Program Plan For Building a Sustained Ocean Observing System for Climate

Updated: March 2005

Overall Summary

The Climate Change Science Program (CCSP) has identified the critical need for the federal government to begin delivering regular reports documenting the present state of the climate system components. Yet an observing system does not presently exist that is capable of accurately documenting climate variability and change in the Earth's oceans, atmosphere, cryosphere, and land surface. Through this program plan NOAA will develop the infrastructure necessary to build, with national and international partners, the ocean component of a global climate observing system and to deliver regular reports on the ocean's contribution to the state of the climate and on the adequacy of the observing system.

1.0 Base Program

1.1 Key activities currently carried out by NOAA for this strategy area: Over the past decade NOAA has worked with national and international partners to begin building a sustained global ocean system for climate, focusing first on the tropical Pacific, and expanding to the Atlantic and the Indian Oceans. It is now well understood that documenting and forecasting climate will require continuous measurements from space along with the instrumenting of the entire global ocean. The present international effort is about 51% of what will ultimately be needed for the global system. NOAA presently maintains approximately 60% of the *in situ* networks and 30% of the space components and is committed to the goal of providing at least 50% of the composite system over the long term.

The existing foundation is comprised of twelve complementary *in situ*, space based, data and assimilation subsystems: 1) Global Tide Gauge Network; 2) Global Surface Drifting Buoy Array; 3) Global Ships of Opportunity Network; 4) Tropical Moored Buoy Network; 5) Argo Profiling Float Array; 6) Ocean Reference Stations; 7) Coastal Moorings; 8) Ocean Carbon Monitoring Network; 9) Arctic observing System; 10) Dedicated Ship Operations; 11) Satellites for Sea Surface Temperature, Sea Surface Height, Surface Vector Winds, Sea Ice, and Ocean Color; 12) Data and Assimilation Systems and their products. The system design is illustrated in Figure 1. This is an international effort. NOAA's plan includes an additional element – System Management and Product Delivery – to focus program resources on answering the nation's highest priority policy- and economically-relevant questions.

The plan is being advanced via matrix management within the NOAA Climate Goal. Implementation of the *in situ* networks is through distributed centers of expertise at the NOAA Research laboratories, the National Ocean Service Center for Operational Oceanographic Products and Services, the National Data Buoy Center, and the university

laboratories that have developed the instruments and techniques. The space components are centered in the NOAA Satellite and Information Service; the space components are being advanced via other NOAA program planning; they are noted here because of their central role in global observation but they are not detailed in this plan. The focal point for developing global ocean data assimilation capabilities will be the Geophysical Fluid Dynamics Laboratory in partnership with the National Centers for Environmental Prediction and university-based applied research centers. The system management functions are focused in the Office of Global Programs.

1.2 Matrix document showing key activities and current status: Illustrated in Figure 2 and detailed below in Section 6.

1.3 Current out-year performance measures based on current funding levels: The performance measures are given in Section 5. At current funding levels the out-year accomplishments will be frozen at the deliverables indicated for FY05.

1.4 Current budget for each of the major activities (FY 2005); based on the total ocean program baseline assessment.

| | |
|------------------------------------|----------------|
| Tide Gauge Network | \$1.8 M |
| Drifting Buoy Array | \$4.0 M |
| Tropical Moored Buoy Network | \$4.8 M |
| Ships-of-Opportunity Network | \$4.6 M |
| Argo Array of Profiling Floats | \$10.4 M |
| Ocean Reference Stations | \$3.7 M |
| Ocean Carbon Monitoring | \$4.0 M |
| Integrated Arctic Observing System | \$1.4 M |
| Dedicated Ship Time | \$1.1 M |
| Data and Assimilation Subsystems | \$3.9 M |
| Management and Product Delivery | <u>\$4.5 M</u> |
| | \$50.4 M |

2.0 Statement of Need

The *Second Report on the Adequacy of the Global Observing System for Climate in Support of the UNFCCC* concludes “there has been progress and improvement in the implementation of global climate observing systems since the first report, especially in the use of satellite information and in the provision of some ocean observations. At the same time, the Report notes that the global terrestrial networks remain to be fully implemented; the ocean networks lack global coverage and commitment to sustained operations; and the atmospheric networks are not operating with the required global coverage and quality. The Report concludes, in agreement with the IPCC, that there remain serious deficiencies in the ability of the current global observing systems for climate to meet the observational needs of the UNFCCC. ...Without urgent action to address these findings, the Parties will lack the information necessary to effectively plan for and manage their response to climate change.”

The Report goes on to note “new technology developed and proven by the ocean climate programs of the 1990s has allowed the ocean community to design and commence implementation of an initial ocean climate observing system that is well focused on the UNFCCC needs. The first priority is the full implementation of this system together with its associated data, analysis and product capabilities.”

In response to the Adequacy Report, the international community has now published the GCOS Implementation Plan for the Global Observing System for Climate in support of the UNFCCC (GCOS-92), October 2004. This implementation plan details the actions needed to achieve global coverage by the ocean networks. The system put in place for climate will also support global weather prediction, global and coastal ocean prediction, marine hazard warning, marine environmental monitoring, and many other non-climate users.

This program plan is founded on the international design noted in GCOS-92; it is illustrated in Figure 1. Other requirement drivers include the CCSP Strategic Plan expressing need for “complete global coverage of the oceans with moored, drifting, and ship-based networks,” and the OCEAN.US *Implementation of the Initial U.S. IOOS* specifying “the highest priority for the global component of the IOOS is sustained, global coverage.” NOAA’s contribution to global implementation is represented in the current program budget and the progress to date is illustrated in Figure 2. Implementation of this program plan will demonstrate to the world community that the United States is intent on taking immediate action to address the Report findings, is willing to play a leadership role in achieving global coverage of the ocean networks, and is committed to sustained operations.

2.1 Program Office requirements to be met: The NOAA Office of Global Programs is organized around four strategic objectives: 1) Development of an Earth System Model for climate change projections at GFDL; 2) Improvement of NWS operational seasonal to international climate forecasts; 3) Development of the in situ ocean component of the global climate observing system; and 4) Development of decision support tools. This plan describes the program for meeting the third objective.

2.2 Input from NOAA leadership related to this strategy: This program plan addresses NOAA’s Strategic Plan, Climate Strategies, and the Annual Guidance Memorandum. In particular:

- Strategic Plan: Describe and understand the state of the climate system through integrated observations, analysis, and data stewardship.
- Climate Strategies: Improve the quality and quantity of climate observations, analysis, interpretation, and archiving by maintaining a consistent climate record and by improving our ability to determine why changes are taking place.
- Annual Guidance Memorandum: The Integrated Ocean Observing System (IOOS) must be developed as a major component of the U.S. contribution to the Global Earth Observation System of Systems (GEOSS).

2.3 External constituent input related to the strategy area: In 2001 the U.S. GOOS Steering Committee conducted a formal review of the 2001 version of this program plan.

The review panel included international representatives of the IOC, IGOS, CLIVAR, WOCE, OOPC, GODAE, and JCOMM as well as partner agencies within the United States – NASA and NAVOCEANO. The seven summary recommendations of the review are paraphrased below.

1. Strong overall support for the plan. U.S. GOOS urged NOAA to implement the plan with the following additional recommendations:
2. The need for a management plan – An effort of the proposed magnitude must be integrated, organized, and managed as a system in order to be effective. The management plan should define an orderly decision making process with management accountability that is understood by other agencies and by customers. A single NOAA point of responsibility and authority is very desirable. Sections 7.0–7.7 achieve this recommendation.
3. The need for a data and information management budget. Section 6.11 achieves this recommendation.
4. The need for improved ocean products – evaluation and delivery. Section 7.6 achieves this recommendation.
5. The need for transition to operations of precision altimetry. Section 6.10 achieves this recommendation.
6. The need for ocean carbon monitoring to be better defined. Section 6.8 achieves this recommendation.
7. The need to deal with dedicated ship time issues. Section 6.9 has been revised to achieve this recommendation.

2.4 Relevant Congressional input or guidance related to the strategy area: The FY03 Senate Committee on Appropriations Report “reaffirms its support for the establishment of an integrated, interagency ocean and coastal observing system ... and requests the submission of a plan to implement such a system.” The National Oceanographic Partnership Program’s Ocean.US office is responding to this Congressional request on behalf of the contributing agencies. The climate system detailed below forms the nucleus of the global component of the U.S. Integrated Ocean Observing System.

2.5 Known impediments (legal, fiscal, policy) towards achieving performance targets and objectives: None.

3.0 Program Initiative

3.1 Overall strategy for addressing deficiencies outlined in the Statement of Need Section. The strategic approach underlying this program plan is as follows:

- Build the long-term ocean component of the observing system in the context of a comprehensive, multi-year, climate services initiative. Improved marine and coastal forecast services will be immediate byproducts.
- Set a 2000-2010 timeline for phased implementation.
- Establish accountability by defining specific objectives and performance measures.
- Define an “initial observing system design” that will accomplish the objectives and performance measures. Identify annual milestones to complete the initial

system over the ten-year time line. Emphasize that the initial design is our best guess at this time – it must be evolutionary as knowledge and technology advance.

- State the obvious – a global observing system cannot be built with existing budgets. Estimate the annual funding needed to achieve the identified milestones. Estimate that NOAA will implement about 50% of the global system.
- Work with national and international partners to achieve 100%.

Although NOAA's marine and coastal services and the mission services of the other agencies and nations will benefit from this plan, and are considered throughout, accomplishing NOAA's climate mission is the fundamental driver. The scientific foundations come from the Climate Variability and Predictability Program (CLIVAR), the Carbon Cycle Science Program, and the Global Water Cycle Program. It is not the intent of the plan to provide all of the observations needed by these programs but to provide a baseline observing system, to be sustained over the long term, that can be built upon where needed to answer specific questions. This baseline system looks for efficiencies to be gained by utilizing common platforms/sites/data infrastructure for several objectives in parallel, and seeks to foster a system approach to effective international organization of complementary in situ, satellite, data, and modeling components of climate observation.

Priorities for implementation are now in place based on the concept of extending the building blocks that have already been put in place, and on the international plan drafted by over 300 scientists from 26 nations that met in Saint Raphael, France, October 1999, at the OCEANOBS 99 Conference for design of *The Ocean Observing System for Climate*. This plan has now been codified in GCOS-92. NOAA will work to implement the specific actions called for in GCOS-92, particularly those actions assigned to the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). JCOMM is NOAA's principal intergovernmental linkage to international implementation.

3.1.1 NOAA context: This plan supports NOAA's strategic goal to monitor and observe: "NOAA will invest in needed climate quality observations and encourage other national and international investments to provide a comprehensive observing system in support of climate assessments and forecasts." The plan details how NOAA will achieve one element of that strategic goal – implementation of the sustained in situ ocean component of the climate observing system.

3.1.2 Interagency context: The observational objectives of NOAA's climate program and those of the CCSP are essentially identical and the ocean observing system architecture detailed below will be implemented by NOAA within the framework of, and as an element of, the CCSP. At the same time the observing system must be advanced in support of climate services, it must also be advanced in response to a national demand for the ocean agencies to coordinate implementation of an U.S. contribution to the global ocean observing system. It is recognized that an effective global ocean observing system can be achieved only through continuing interaction among all national (and international) partners. In this context, NOAA will provide a significant contribution to

the global component of the Integrated Ocean Observing System. Implementation will be coordinated with the National Oceanographic Partnership Program agencies.

3.1.3 International context: The observational component of climate services has by far the greatest opportunity and necessity for international collaboration. A global observing system by definition crosses international boundaries and the potential exists for both benefits and responsibilities to be shared by many nations. The system described below is based on the international design of, and is an U.S. contribution to GCOS-92. The observing system projects that make up the climate component have been developed, and will continued to be evolved, organized and managed, in cooperation with the international implementation panels of the Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology (JCOMM), and with scientific guidance from the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC).

3.2 Proposed out-year performance targets: See Sections 5.0-5.4.

3.3 Discussion of individual investments necessary to address shortfalls: Given in Sections 6.0-7.7.

3.4 Cost and schedule for each investment: Based on the Program Baseline assessment of the 100% requirement. Details given in Table 2. Summary:

| | <u>FY03</u> | <u>FY04</u> | <u>FY05</u> | <u>FY06</u> | <u>FY07</u> | <u>FY08</u> | <u>FY09</u> | <u>FY10</u> |
|-------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| System annual operating cost (\$ M) | 35.2 | 40.7 | 50.4 | 53.6 | 76.0 | 101.3 | 120.8 | 141.5 |

4.0 Program Goal and Objectives

4.1 Goal

The goal of this plan is to build and sustain the ocean component of a global climate observing system that will respond to the long-term observational requirements of the operational forecast centers, international research programs, and major scientific assessments.

4.2 Objectives

The ocean is the memory of the climate system and is second only to the sun in effecting variability in the seasons and long-term climate change. It is estimated that the ocean stores 1000 times more heat than the atmosphere, and 50 times more carbon. Eighty-five percent of the precipitation that waters our Earth comes directly from the ocean. Changing sea level is one of the most immediate impacts of climate change. Additionally, the key to possible abrupt climate change may lie in deep ocean circulation.

Accordingly, the objectives of the sustained ocean observing system for climate are to:

- 1) Document long-term trends in sea level change;
- 2) Document ocean carbon sources and sinks;
- 3) Document the ocean's storage and global transport of heat and fresh water; and

- 4) Document the ocean-atmosphere exchange of heat and fresh water.

This implementation plan will provide a composite global ocean observing system of complementary networks that includes: 1) deployment and maintenance of observational platforms and sensors; 2) data delivery and management; and 3) routine delivery of ocean analyses. This end-to-end ocean system will provide the critical “up-front” information needed for climate forecasting, research, and assessments – continuous, long term, climate quality, global data sets and a suite of routinely delivered ocean analyses. At the same time, the system will provide real-time data to serve the needs of NOAA’s marine and coastal forecast and warning missions and the needs of the other agencies in accomplishing their missions.

5.0 Performance Measures

In order to achieve the four objectives, the system must accurately measure: 1) sea level to identify changes resulting from climate variability; 2) ocean carbon content every ten years and the air-sea exchange seasonally; 3) sea surface temperature and surface circulation to identify significant patterns of climate variability; 4) sea surface pressure and air-sea exchanges of heat, momentum, and fresh water to identify changes in forcing functions driving ocean conditions and atmospheric conditions; 5) ocean heat and fresh water content and transports to identify where anomalies enter the ocean, how they move and are transformed, and where they re-emerge to interacting with the atmosphere; 6) identify the essential aspects of thermohaline circulation as well as the subsurface expressions of the patterns of climate variability; and 7) sea ice thickness and concentrations.

The sampling requirements for these parameters have been documented by international GOOS and GCOS. Table 1 lists the requirements as presented at the OCEANOBS 99 Conference in Saint-Raphael, France. It represents the best estimates of the international community at this time.

The Proceedings of OCEANOBS 99 and the final report from the conference, *Observing the Ocean in the 21st Century*, outline implementation strategies for achieving these sampling requirements. Additionally, for documenting sea level variability and change, the implementation strategy is further defined in the *International Sea Level Workshop Report*, 1998; and for documenting ocean carbon sources and sinks the implementation strategy is defined in the *Large Scale CO₂ Observing Plan: In Situ Oceans and Atmosphere (LSCOP)*, 2002. The latter plan is for the United States only at this time, but was developed by U.S. scientists working in collaboration with international partners. The international community met in Paris, January 2003, to advance international implementation of the ocean carbon monitoring system and the results have now been published in the International Ocean Carbon Coordination Project. The elements of the plans needed to achieve global coverage with an initial ocean observing system have now been summarized in GCOS-92. These foundation documents are available from the NOAA Office of Global Programs and are listed in Appendix A.

Based on the requirements in Table 1 and the implementation strategies defined in the foundation documents listed in Appendix A, the system's effectiveness in meeting the objectives will be gauged by the performance measure listed below. Detailed metrics are given for each objective in sections 5.1-5.4. Those detailed metrics will lead to a system that can be summarized in four overarching measures of success:

Performance Measure 1: Reduce the error in global measurement of sea surface temperature.

Metric: Potential satellite bias error (degrees Celsius):

| 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.7 C | 0.7 C | 0.6 C | 0.5 C | 0.4 C | 0.3 C | 0.2 C | 0.2 C | 0.2 C |

Performance Measure 2: Reduce the error in global measurement of sea level variability and change.

Metric: To be determined

Performance Measure 3: Reduce the error in global measurement of ocean carbon sources and sinks.

Metric: To be determined

Performance Measure 4: Reduce the error in global measurement of the ocean's storage and transport of heat and fresh water.

Metric: To be determined

5.1 Document long-term trends in sea level change.

Performance Measure 5: Complete the installation of real-time, remote reporting tide gauges and co-located permanent GPS receivers at the international GLOSS subset of 62 stations for Long Term Trends and subset of 30 stations for altimeter drift calibration.

Performance Measure 6: Establish the permanent infrastructure necessary to process and analyze the tide gauge and GPS data and deliver routine annual sea level change reports.

Metrics:

- For 170 climate reference stations worldwide, routinely deliver an annual report of the variations in relative annual mean sea level for the entire length of the instrumental record, and the monthly mean sea level trend for the past 100 years with 95% confidence interval.
- Routinely deliver an annual report of global absolute sea level change to an accuracy of 1 mm per year.

5.2 Document ocean carbon sources and sinks.

Performance Measure 7: Complete the Northern Hemisphere ocean observing system to assist in determining carbon dioxide sources and sinks over the coterminous United States in partnership with the atmospheric observing system.

Performance Measure 8: Complete the expansion of the global oceanic observing system to inventory global scale oceanic uptake of excess carbon dioxide in partnership with the atmospheric observing system.

Metrics:

- Report interhemispheric gradients of CO₂ constrained to 1 ppm on seasonal time scales.
- Improve measurements of North Atlantic and North Pacific Ocean basin carbon dioxide fluxes to within ± 0.2 Pg/C per year.
- Reduce uncertainty on regional estimates of carbon sources and sinks on a global basis to $\pm 50\%$.
- Report the change in ocean carbon inventory over the last decade constrained to 2 Pg/C per year.
- Provide publicly available, routine changes in inventory of carbon, heat, and salinity in the ocean basins on a decadal time frame to assess the effect of global change and feedbacks on the ocean

5.3 Document the ocean's storage and global transport of heat and fresh water.

Performance Measure 9: For the global ocean, complete the ocean observing system needed to measure the global variations in sea surface temperature, surface and 2000 m circulation, total heat content of the ocean, and the transport of heat across and between all ocean basins.

Performance Measure 10: Design, deploy, and implement instrument and analysis systems to provide long term integrated measures of the global thermohaline circulation and deliver yearly estimates of the state of the thermohaline circulation - intensity, properties, freshwater transport.

Metrics:

- At ocean reference stations, deliver routine annual analyses of variability in average temperature at 0-1000 m depth to 0.1°C, and seasonal average temperature change to 0.1°C per three months.
- Deliver analyses of the seasonal means of the surface and 2000 m ocean velocity fields on appropriate spatial resolutions that capture the major features of the overturning circulation for all the core climate variability regions (the global tropics, Pacific Decadal Oscillation, North Atlantic Oscillation, high latitude water mass formation regions both northern and southern hemispheres).
- Deliver analyses of monthly mean sea surface temperature anomaly at 500 km resolution to 0.2°C accuracy, average temperature at 0-1000 m depth to 0.5°C accuracy, and annual average temperature change to 0.5°C per year.
- For the sinking regions of the north Atlantic and southern hemisphere, deliver yearly estimates of the annual average temperature and salinity of the intermediate, deep, and bottom waters to 0.03°C and 0.03PSU.

- Across zonal sections in the Atlantic at 24°N, 47°N, and globally at 35°S, deliver estimates of the average annual meridional heat transport from surface to bottom at 0.3PWatt accuracy.

5.3 Document the ocean-atmosphere exchange of heat and fresh water.

Performance Measure 11: For the global tropical ocean belt, complete the upper ocean and surface meteorology observing system needed to measure the ocean-atmosphere exchange of heat.

Performance Measure 1: For the global ocean, complete the oceanographic, surface meteorology, and analysis system needed to measure variability in the ocean-atmosphere exchange of fresh water, i.e., precipitation and evaporation.

Metrics:

- For the global ocean, deliver analyses of weekly mean sea surface temperature at 500 km resolution to 0.2°C accuracy
- At ocean reference stations, deliver routine annual analyses of variability in ocean-atmosphere flux to 10 W/m².
- For the global ocean deliver weekly analysis of precipitation and evaporation at 500 km resolution to 5 cm per month accuracy.

6.0 Milestones

In order to achieve the Performance Measures, the integrated ocean observing system will be completed according to the following schedule. The schedule is based on the initial design and projections of adequate funding. The milestones will be updated annually to reflect evolution of the design as knowledge and technology advance, and to reflect the realities of funding availability.

| | FY02 | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 |
|--------------------|------|------|------|------|------|------|------|------|------|
| System % Complete: | 40 | 45 | 48 | 53 | 55 | 66 | 77 | 88 | 100 |

Although individual network priorities are described below, they must all go forward together as a system. For example, the global Argo array of profiling floats is a primary tool for documenting ocean heat content; yet deployment of the floats in the far corners of the ocean cannot be achieved without the ships-of-opportunity and dedicated ship time elements; and the Argo array cannot do its work without global over-flight by continued precision altimeter space missions; while the measurements taken by all networks will be rendered effective only through the data and assimilation subsystems.

The following sections indicate network improvements that work toward building the observing system as a whole. The ocean observing system is a composite of complementary networks, each one contributing its unique strengths; most serve multiple purposes. One of the primary goals of NOAA's Office of Climate Observation is to look for efficiencies to be gained by utilizing common platforms/sites/data infrastructure for

several objectives in parallel. For these reasons it is difficult to assign the network components specifically to the climate service product lines on a one-to-one basis. In general, however, the network tasks described below will contribute to the deliverables as follows:

- 1) Document long-term trends in sea level change:
 - Tide Gauge Network
 - Satellites
 - Data and Assimilation Subsystems
- 2) Document ocean carbon sources and sinks:
 - Drifting Buoy Array
 - Tropical Moored Buoy Network
 - Ships of Opportunity
 - Argo Array
 - Ocean Reference Stations
 - Ocean Carbon Measurements
 - Coastal Moorings
 - Dedicated Ship Time
 - Data and Assimilation Subsystems
- 3) Document the ocean's storage and global transport of heat and fresh water:
 - Tide Gauge Network
 - Drifting Buoy Array
 - Tropical Moored Buoy Network
 - Ships of Opportunity
 - Argo Array
 - Ocean Reference Stations
 - Coastal Moorings
 - Arctic Observing System
 - Dedicated Ship Time
 - Satellites
 - Data and Assimilation Subsystems
- 4) Document the ocean-atmosphere exchange of heat and fresh water:
 - Drifting Buoy Array
 - Tropical Moored Buoy Network
 - Ships of Opportunity
 - Argo Array
 - Ocean Reference Stations
 - Coastal Moorings
 - Arctic Observing System
 - Dedicated Ship Time
 - Satellites
 - Data and Assimilation Subsystems

Priorities and milestones for the individual networks follow. For each network the several priority tasks are listed in tabular form. The bottom lines of the tables give the representative milestones that are shown graphically in Figure 2; representative milestones are used to simplify the graphic depiction of the phased implementation plan illustrated by Figure 2. Relative emphases in completing the several components of the observing system will depend on the relative priorities assigned to the network tasks in the context of the overall requirements of climate services.

6.1 Tide Gauge Network: Tide gauges are necessary for accurately measuring long-term trends in sea level change and for calibration and validation of the measurements from satellite altimeters, which are assimilated into global climate models for predicting climate variability. Many tide stations need to be upgraded with modern technology. Permanent GPS receivers will be installed at a selected subset of stations, leading to a geocentrically located subset expansion from the present 43 GPS sites to 170 sites globally by 2010. These 170 climate reference stations will also be upgraded for real-time reporting, not only for climate monitoring, but also to support marine hazard warning (e.g., tsunami warning). In cooperation with international partners NOAA will maintain a global climate network of 199 tide gauges stations, including the subset noted above, for validation of satellite retrievals, validation of climate model results, and documentation of seasonal to centennial variability in the El Nino Southern Oscillation, Indian Ocean and Asian-Australian monsoons, tropical Atlantic variability, North Atlantic Oscillation, North Pacific variability, high latitude circulation, western boundary currents, and circulation through narrow straits and chokepoints. This task will contribute to climate services by providing the long term records needed to 1) document sea level change; 2) document heat uptake, transport, and release by the ocean (sea surface height contributes to the measurement of ocean heat content); and 3) documents the ocean's overturning circulation (gradients of sea surface height across straights and choke-points are used to calculate large-scale ocean currents).

| | NOAA Contributions | | | | | | | | International Goal |
|-------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational stations | 57 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 107 |
| Research stations | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Station upgrades | 0 | 4 | 10 | 16 | 26 | 32 | 32 | 32 | 199 |
| GPS installation | 5 | 10 | 14 | 43 | 45 | 52 | 62 | 86 | 86 |
| Real-time reporting | 67 | 69 | 79 | 91 | 106 | 126 | 148 | 170 | 170 |
| GPS data processing | | | X | X | X | X | X | X | X |
| Technology development | | | | X | X | X | X | X | X |
| International GPS/DORIS | 37 | 39 | 43 | 45 | 52 | 62 | 86 | 86 | 86 |

6.2 Drifting Buoy Array: Data sparse regions of the global ocean are a major source of uncertainty in the seasonal forecasts and are also a major uncertainty in the detection of long-term trends in global sea surface temperature, which in turn is an indicator of global change. Data gaps must be filled by surface drifting buoys to reduce these sources of error to acceptable limits. NOAA, together with international partners, will extend the global SST/velocity drifting buoy array to data sparse regions, increasing from 1050 to 1250 buoys by 2005, while adding wind, pressure, and precipitation measurement capabilities to serve short term forecasting as well as climate research, seasonal forecasting, and assessment of long term trends. This task will support climate services by providing measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks (sea surface temperature affects the rate of transfer of CO₂ between the ocean and atmosphere; 3) document the air-sea exchange of water and the ocean's overturning circulation, and 4) document sea level change by providing the sea surface atmospheric pressure measurements that are essential for calculating sea surface height from satellite altimeter measurements.

| | NOAA Contributions | | | | | | | | International Goal |
|--------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational buoys | 420 | 670 | 1040 | 1040 | 1040 | 1040 | 1040 | 1040 | 1250 |
| Research buoys | 200 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Add met sensors | 40 | 40 | 500 | 670 | 670 | 670 | 670 | 670 | 1250 |
| Technology development | | | X | X | X | X | X | X | X |
| International array size | 787 | 1050 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |

6.3 Tropical Moored Buoy Network: Most of the heat from the sun enters the ocean in the tropical/sub-tropical belt. The advanced understanding of the role of the tropics in forcing mid-latitude weather and climate was learned primarily through the observations of the tropical moored buoy array (TAO/TRITON) in the Pacific. A similar pilot array in the Atlantic basin (PIRATA) now offers the potential of even better understanding, improved forecasts, and improved ability to discern the causes of longer-term changes in the Oceans. In addition to monitoring the air-sea exchange of heat, the moored buoys provide platforms for supporting instrumentation to measure carbon dioxide and rainfall in the tropics. The global tropical moored buoy network will be expanded from 82 to 119 stations by 2010 and will ultimately span all three oceans - Pacific, Atlantic, and Indian Ocean. This task will support climate services by providing both ocean and atmospheric observations to 1) document heat uptake, transport, and release by the ocean; 2) document carbon sources and sinks; and 3) document the air-sea exchange of fresh water.

| | NOAA Contributions | | | | | | | | International Goal |
|------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational buoys | 55 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 79 |
| Research buoys | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Indian Ocean expansion | | 3 | 6 | 15 | 15 | 15 | 15 | 33 | 33 |

| | | | | | | | | | |
|------------------------------|----|----|----|----|----|-----|-----|-----|-----|
| Atlantic Ocean expansion | | | 2 | 2 | 5 | 5 | 5 | 5 | 9 |
| Add salinity sensors | 10 | 10 | 60 | 65 | 65 | 65 | 65 | 65 | 99 |
| Add flux capability to buoys | | | 5 | 5 | 5 | 5 | 5 | 5 | 8 |
| Technology development | | | X | X | X | X | X | X | X |
| International network size | 79 | 79 | 82 | 84 | 90 | 100 | 115 | 115 | 115 |

6.4 Ships of Opportunity: The global atmospheric and oceanic data from Ships of Opportunity (SOOP) have been the foundation for understanding long-term changes in marine climate and are essential input to climate and weather forecast models. Improved instrument accuracy, automated reporting, and improved information about how the observations were taken will greatly enhance the quality of these data, reducing both systematic and random errors. NOAA will improve meteorological measurement capabilities on the global SOOP fleet for improved marine weather and climate forecasting in general, and will concentrate on a specific subset of high accuracy SOOP lines to be frequently repeated and sampled at high resolution for systematic upper ocean and atmospheric measurement. This climate-specific subset will build from 27 lines presently occupied to a designed global network of 51 lines by 2008 and will provide measurements of the upper ocean thermal structure, sea surface temperature and chemistry, and surface meteorology of high accuracy. Additionally, the SOOP fleet is the primary vehicle for deployment of the drifting arrays. This task will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; and 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below); and 3) document the air-sea exchange of water and the ocean's overturning circulation.

| | NOAA Contributions | | | | | | | | International Goal |
|---------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational HRX lines | 2 | 15 | 21 | 21 | 21 | 21 | 21 | 21 | 26 |
| Research HRX lines | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Frequently repeated lines | 4 | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 25 |
| Add flux/salinity HRX | 2 | 2 | 7 | 12 | 15 | 15 | 15 | 15 | 26 |
| Auto-met package, VOSCLIM | 0 | 0 | 40 | 100 | 200 | 200 | 200 | 200 | 200 |
| Technology development | | | | X | X | X | X | X | X |
| International lines | 26 | 29 | 40 | 40 | 45 | 45 | 51 | 51 | 51 |

6.5 Argo array of profiling floats: The heat content of the upper 2000 meters of the world's oceans, and the transfer of that heat to and from the atmosphere, are variables

central to the climate system. The Argo array of profiling floats is designed to provide essential broad-scale, basin-wide monitoring of the upper ocean heat content. Three thousand floats will be deployed worldwide by 2006. The U.S. contribution is approximately one-half of this international project. Glider technology will replace standard drifting Argo floats in the boundary currents and targeted deep circulation regions. This task will support climate services by providing measurements needed to 1) document heat uptake, transport, and release by the ocean; and 2) document the air-sea exchange of water and the ocean's overturning circulation.

| | NOAA Contributions | | | | | | | | International Goal |
|--------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational Argo floats | 320 | 1000 | 1500 | 1485 | 1485 | 1385 | 1385 | 1385 | 2800 |
| Research Argo floats | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Operational gliders | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 200 |
| Research gliders | 3 | 3 | 10 | 20 | 50 | 0 | 0 | 0 | 0 |
| Technology development | | | | X | X | X | X | X | X |
| International array size | 1000 | 1500 | 2300 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 |

6.6 Ocean Reference Stations:

6.6.1 Subtask 1: NOAA, together with international partners, will implement a global network of ocean reference station moorings, expanding from the present six pilot stations to a permanent network of 21 (plus 8 within the tropical moored buoy network) by 2010. NSF's Ocean Observatories Initiative will provide a major piece of the infrastructure needed for this network, establishing high-capability re-locatable moored buoys in remote ocean locations. NOAA will maintain climate instrumentation aboard the NSF-supplied platforms.

6.6.2 Subtask 2: Monitoring the transport within the ocean is a central element of documenting the overturning circulation of fresh water and heat and carbon uptake and release; heat and carbon generally are released to the atmosphere in regions of the ocean far distant from where they enter. Long-term monitoring of key choke points, such as the Indonesian through-flow, and of boundary currents along the continents, such as the Gulf Stream, must be established to measure the primary routes of ocean heat, carbon, and fresh water transport.

6.6.3 Subtask 3: Monitoring thermohaline circulation is a central element of documenting the ocean's overturning circulation and a critical need for helping scientists understand the role of the ocean in abrupt climate change. It is essential that the ocean observing system maintain watch at a few control points at critical locations. Key monitoring sites have been identified by an international team of scientists for deployment of long-term subsurface moored arrays and repeated temperature, salinity, and chemical tracer surveys from research vessels. NOAA will focus with Canadian partners on monitoring the Labrador Sea and upstream locations in Davis Strait and the

Canadian Arctic Archipelago, while European partners will focus on the eastern north Atlantic. One exception to this is that NOAA will maintain the Greenland-Iceland-Norwegian (GIN) Seas times-series that was started in 1991. Additionally, to estimate the effect of Antarctic zone water on the global thermohaline circulation, NOAA will maintain time series moorings and repeat sections in the northwestern Weddell Sea, and will establish time series measurements in the Ross Sea. These locations are important to examine the variability of water mass transformation processes as they relate to climate variability in the Southern Ocean.

6.6.4 Summary: These three subtasks will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

| | NOAA Contributions | | | | | | | | International Goal |
|---------------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Operational flux moorings | 1 | 2 | 6 | 7 | 9 | 9 | 9 | 9 | 29 |
| Research flux moorings 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Operational full depth stations | 0 | 0 | 3 | 5 | 10 | 10 | 10 | 10 | 42 |
| Research full depth stations | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Operational transport stations | 0 | 0 | 2 | 4 | 4 | 5 | 5 | 5 | 10 |
| Research transport stations | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pacific Raingauge (PACRAIN) | 0 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Research rain gauge network | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Operational GIN time series | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Research GIN time series | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sinking regions, operational | 0 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 5 |
| Sinking regions, research | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| S. Hemisphere sections | 0 | 0 | 0 | 2 | 3 | 3 | 3 | 3 | 3 |
| Technology development | | | | X | X | X | X | X | X |
| International flux array | 6 | 7 | 10 | 14 | 16 | 29 | 29 | 29 | 29 |

6.7 Coastal Moorings: Improved near shore measurements from moored buoys are critical to coastal forecasting as well as to linking the deep ocean to regional impacts of climate variability. The boundary currents along continental coastlines are major movers of the ocean's heat and fresh water (e.g., the Gulf Stream). Furthermore, the coastal regions are critical to the study of the role of the ocean in the intensification of storms, which are key to the global atmospheric transport of heat, momentum and water, and are a significant impact of climate on society. Coastal arrays are maintained by many nations making this a "global" network of "coastal" stations. A climate subset of NOAA's existing network will be improved by augmenting and upgrading the instrument suite to provide measurements of the upper ocean as well as the sea surface and surface meteorology. Ten of these moorings will serve as platforms-of-opportunity for the addition of carbon sampling instrumentation. This task will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake,

transport, and release by the ocean; 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below); and 3) document the air-sea exchange of water.

| | NOAA Contributions | | | | | | | | International Goal |
|-------------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Upgrade w/climate sensors | 0 | 0 | 20 | 65 | 65 | 65 | 65 | 65 | 105 |
| Technology development | | | | X | X | X | X | X | X |
| International coastal network | 0 | 0 | 20 | 85 | 95 | 105 | 105 | 105 | 105 |

6.8 Ocean Carbon: Understanding the global carbon cycle and the accurate measurement of the regional sources and sinks of carbon are of critical importance to international policy decision making as well as to forecasting long term trends in climate. Projections of long-term global climate change are closely linked to assumptions about feedback effects between the atmosphere, the land, and the ocean. To understand how carbon is cycled through the global climate system, ocean measurements are critical. NOAA will add autonomous carbon dioxide sampling to the moored arrays and the VOS fleet to analyze the seasonal variability in carbon exchange between the ocean and atmosphere, and in cooperation with NSF will implement a program of systematic global ocean surveys that will provide a complete carbon inventory once every ten years. This task is coordinated with the Global Carbon Cycle Science program, is dependent on implementation of the ship lines and moored and drifting arrays, and will support climate services by providing measurements to document ocean carbon sources and sinks.

| | NOAA Contributions | | | | | | | | International Goal |
|---------------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Inventory lines per decade | 6 | 6 | 11 | 11 | 11 | 11 | 11 | 11 | 25 |
| Time series moorings | 2 | 2 | 4 | 6 | 6 | 6 | 6 | 6 | 12 |
| Coastal flux moorings | 0 | 0 | 0 | 11 | 11 | 11 | 11 | 11 | 29 |
| Flux on ships of opportunity | 4 | 7 | 12 | 12 | 12 | 12 | 12 | 12 | 21 |
| Research flux on moorings | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trans rsch flux moorings to ops | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Technology development | | | X | X | X | X | X | X | X |
| International flux array | 14 | 17 | 28 | 38 | 48 | 62 | 62 | 62 | 62 |

6.9 Integrated Arctic Observing System: To understand the role of the Arctic on global environmental change, the amount of uncertainty in the causes and trajectories of global climate change needs to be reduced. Given the sensitivity of the Arctic environment to climate variability and change, it is in this region that early indications of the future progression of climate change are likely to be first detected.

Ocean Climate Observations in the Arctic Ocean and Northern High Latitude Seas – A program of sustained observations of this area is being conducted through dedicated and shared ship-based cruises and permanent oceanographic moorings, supplemented by acquisition and analysis of historical data sets. The long-term goal is to detect climate-driven physical and ecological change, especially due to changes in sea ice extent and duration, and in ocean density and circulation that together may lead to changes in ocean heat transport, productivity, and food web structure. International collaboration is essential for completing this program, especially with Russia and Canada. In FY2003, one new mooring was deployed in the Northern Bering Sea, a research cruise was conducted to the Chukchi Sea in collaboration with China, planning was initiated for a future Chukchi Sea cruise in collaboration with Russia, sea-glider deployments were initiated in the Labrador Sea, joint US-Canada observations were conducted in Barrow Strait, and efforts begun to discover, obtain and manage historical data sets.

Arctic Sea Ice Observations – Ice-tethered buoys and bottom-mounted moorings are deployed to monitor the drift of Arctic sea ice and to determine its thickness. The long-term goal is to provide an accurate record of changes in sea ice thickness that, together with satellite observations of sea ice extent, can provide an estimate of changes in sea ice volume. This information is critical for improvement of global climate models and development of a regional Arctic climate model. Several ice buoys and two ice thickness stations were deployed in summer 2004.

This task will support climate services by providing ocean and ice measurements needed to document heat uptake, transport, and release by the ocean.

| | NOAA Contributions | | | | | | | | International Goal |
|-------------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Arctic pathway moorings | 0 | 0 | 1 | 2 | 4 | 6 | 8 | 8 | 12 |
| Arctic Ocean moorings | 0 | 0 | 1 | 2 | 4 | 6 | 7 | 7 | 8 |
| ASOF gateway mooring sets | 0.5 | 0.5 | 1 | 1 | 1 | 1 | 2 | 2 | 5 |
| Automated drifting stations | 0 | 0 | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| Ice buoys | 10 | 10 | 11 | 20 | 20 | 20 | 20 | 20 | 40 |
| Hydrographic stations | 0 | 0 | 1 | 4 | 6 | 8 | 9 | 10 | 16 |
| Bering Sea moorings | 1 | 1 | 1 | 2 | 4 | 6 | 6 | 6 | 6 |
| Western boundary sections | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Western boundary moorings | 0 | 0 | 2 | 2 | 4 | 4 | 4 | 4 | 4 |
| Ice buoys and moored stations | 10 | 31 | 36 | 36 | 54 | 64 | 78 | 85 | 85 |

6.10 Dedicated Ship Time:

6.10.1 Subtask 1: Climate Ship time within the UNOLS research fleet for deployment of the moored and drifting arrays, and for deep ocean surveys is an essential component of this initiative. The deep ocean cannot be reached by SOOP and Argo; yet quantification of the carbon and heat content of the entire ocean column is needed to solve the climate equations. In addition to providing the survey and deployment platforms for the autonomous arrays, the research fleet will maintain sensor suites on a small core of vessels as the highest quality calibration points for validation of the other system measurements. Annual requirements for ship time are 54 days in addition to the Ka'imimoana for TAO/TRITON maintenance, 74 days for the carbon inventory, 34 days for PIRATA in addition to the French/Brazilian support (see Subtask 2), 47 days for ocean reference stations growing to 120 days, 60 days for deployment of the drifting arrays in remote regions, and 46 days for thermohaline circulation monitoring growing to 172 days.

6.10.2 Subtask 2: The PIRATA array has been maintained by French research vessels, once per year in the east, and the Brazilian navy once per year on the western side of the Atlantic. Two maintenance visits per year to each mooring are necessary to maintain adequate operational data flow, as has been demonstrated in the Pacific with the TAO/TRITON array. The PIRATA consortium (Brazil, France, U.S.A.) has proposed a plan to establish an international ship base in Natal, Brazil, and operate cooperatively a new ship dedicated to Atlantic climate operations. The consortium has proposed that NOAA and French partners cooperate to acquire a new ship, and build the capacity in Brazil to support long-term climate operations. The new ship would support Argo and drifter deployments as well as PIRATA maintenance. The U.S. homeport for the ship, and support base for north Atlantic operations, would be Charleston, SC; Natal would support operations in the tropical and south Atlantic. This is a new concept in international collaboration and capacity building. In 2003, NOAA began feasibility study together with French and Brazilian partners to identify the best long-term solution to this issue. In the mean time, NOAA will begin supplementing the once-per-year French and Brazilian maintenance cruises with a second maintenance cruise using UNOLS or other charter operations (see Subtask 1).

6.10.3 Summary: This task will support climate services by providing multi-use platforms for the ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

| Ship days at sea | NOAA Contributions | | | | | | | | International Goal | |
|-----------------------|--------------------|------|------|------|------|------|------|------|--------------------|-----|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | | |
| Ka'imimoana | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 |
| TAO/TRITON additional | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 90 |
| PIRATA | 0 | 0 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 124 |
| Carbon survey | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 74 | 240 |
| Coastal flux maps | 0 | 0 | 0 | 36 | 40 | 40 | 40 | 40 | 40 | 240 |

| | | | | | | | | | |
|-------------------------------|-----|-----|-----|-----|------|------|------|------|------|
| Reference Stations | 47 | 47 | 47 | 60 | 102 | 120 | 120 | 120 | 480 |
| Deployment of drifting arrays | 0 | 0 | 0 | 60 | 60 | 60 | 60 | 60 | 100 |
| Thermohaline circulation | 46 | 46 | 46 | 46 | 90 | 172 | 172 | 172 | 340 |
| Arctic hydrographic sections | 0 | 0 | 0 | 60 | 60 | 60 | 60 | 60 | 120 |
| NOAA total | 497 | 497 | 531 | 531 | 640 | 730 | 830 | 830 | |
| International fleet | 550 | 610 | 750 | 900 | 1200 | 1620 | 1620 | 1620 | 1620 |

6.11 Satellites:

The initial ocean observing system for climate depends on space based global measurements of 1) sea surface temperature, 2) sea surface height, 3) surface vector winds, and 4) ocean color. These satellite contributions are detailed in other NOAA program plans.

6.11.1 Sea surface temperature: Satellite measurements of sea surface temperature are included in NOAA's operational satellite program and the NPOESS program. Satellite data provide high-resolution sea surface temperature data. Both infrared and microwave satellite data are important. Microwave sea surface temperature data have a significant coverage advantage over infrared sea surface temperature data, because microwave data can be retrieved in cloud-covered regions while infrared cannot. However, microwave sea surface temperatures are at a much lower spatial resolution than infrared. In addition microwave sea surface temperatures cannot be obtained within roughly 50 km of land. A combination of both infrared and microwave data are needed because they have different coverage and error properties. Drifting buoy and other *in situ* data are critically important in providing calibration and validation in satellite data as well as providing bias correction of these data. Satellite biases can occur from orbit changes, satellite instrument changes and changes in physical assumptions on the physics of the atmosphere (e.g., through the addition of volcanic aerosols). Thus, drifting buoy and other *in situ* data are needed to correct for any of these changes.

6.11.2 Sea surface height: The value of spaced-based altimeter measurements of sea surface height has now been clearly demonstrated by the TOPEX/Poseidon and Jason missions. Changes in sea level during major El Nino events can now be discerned at high resolution and provide realistic model initializations for seasonal climate forecasting. The same data, when calibrated with island tide gauge observations, are also able to monitor the rate of global sea level change with an accuracy of 1 mm per year. The planned NPOESS altimeter will be adequate for shorter term forecasting, but the NPOESS altimeter will not fly in the same orbit as TOPEX/Poseidon and Jason; and for monitoring long-term sea level change, continuation of precision altimeter missions in the TOPEX/Poseidon/Jason orbit is necessary. Jason follow-on altimeter missions (Ocean Surface Topography Mission, OSTM) are necessary to continue the long-term sea level record. NASA and CNES have asked NOAA and EUMETSAT to transition the Jason-class altimeter from research to operations beginning with the OSTM. In FY2006, NOAA will assume primary U.S. responsibility for continuing this international effort. This task will contribute to climate services by providing the long term records needed to 1) document sea level change; 2) document heat uptake, transport, and release by the ocean;

and 3) document the ocean's overturning circulation (sea surface height contributes to the measurement of ocean heat and fresh water content and their transport).

6.11.3 Surface vector winds and ocean color: The best methods of sustaining satellite measurement of surface vector winds and ocean color are still a research and development question; over the next five years NOAA, NASA, and NPOESS will weigh the alternatives and determine the long term strategy for maintenance of these elements.

6.12 Data and Assimilation Subsystems:

6.12.1 Subtask 1 – Long Term Stewardship: The value of the observations does not end with their initial use in detecting and forecasting climate variability. The data must be retained and made available for retrospective analyses to understand long-term climate change, and for designing observing system operations and improvements. NOAA's long history and unique expertise in environmental data management will be applied to the ocean observing system. NOAA also will include the vast holdings of historical ocean observations within the context of the integrated environmental data access and archive system. Support will also be provided for a World Ocean Database to incorporate modern data into an integrated profile system.

6.12.2 Subtask 2 – Data Management and Communications: A robust and scalable data management infrastructure is essential to the vision of a sustained ocean observing system. NOAA's ocean climate data element will contribute a global component to the Data Management and Communications System (DMAC) of the U.S. Integrated Ocean Observing System (IOOS) that is being implemented by the National Oceanographic Partnership Program agencies. The DMAC plan integrates data transport, quality control, data assembly, limited product generation, metadata management, data archeology, data archival, data discovery, and administration functions. Uniform access to data will be addressed through the concept of "middleware" connectivity – a common set of standards and protocols that connects all data sources to data users. The middleware approach shields end users from many of the traditional barriers that have been associated with climate data access, including file formats, the distributed location of data, and the large size of some data sets. The preliminary design has been developed by the National Virtual Ocean Data System (NVO DS) project.

The nature of IOOS requires the DMAC to be very highly distributed, supporting both large and small data providers at Federal, regional, state, municipal and academic levels. Data assembly centers will be built into the design to add fault-tolerance and increase ease of use. The GODAE server at Navy's Fleet Numerical Modeling Operations Center (FNMOC) in Monterey will provide robust, operational access to aggregated and quality-controlled real-time data streams and will be a primary assembly center for NOAA's real-time global measurements. Delayed-mode data sources will be distributed across many institutions including the Asia-Pacific Research Data Center (APDRC) (part of the International Pacific Research Center (IPRC) at the University of Hawaii) and the NOAA Data Centers. The APDRC will provide data assembly services for delayed-mode observations in a cooperative partnership with the GODAE Server.

The Data Management and Communications component of NOAA's ocean climate observing system must also deliver the information products needed by NOAA scientists and managers for decision support. The products must provide the information needed to monitor the month-by-month effectiveness of the observing system and to diagnose problems. The products should include intelligible scientific graphics and human-readable numeric tables that provide an overview of the integrated system, selectively merging the data from all relevant measurement streams. These information products will be a component of NOAA's contribution to IOOS.

6.12.3 Subtask 3 – Four dimensional data assimilation including GODAE: For climate forecasting, the combined fields from many different networks are used as initial conditions to begin the forecast. These combined fields, or analyses, are also used to document what the ocean and atmosphere are doing at present and what they did in the past, thus providing a record of the changing climate. By routinely comparing models and data, shortcomings in the observing system can be identified and both the models and forecasts can be improved. To utilize effectively the ocean observations, NOAA will expand the current ocean analyses (presently focused on the tropical Pacific) to the global domain and will develop and implement improved assimilation subsystems that can more effectively use the new data types that are being collected. The principal vehicle for developing this capability, involving both national and international communities and producing a variety of marine products in addition to the use of these observations in forecast systems, will be the Global Ocean Data Assimilation Experiment (GODAE). The global data and ocean product delivery will be operationalized as a contribution to, and continue as a follow-on to, GODAE through the interagency/international server infrastructure being implemented by GODAE for real-time at FNMOC and for delayed mode at the IPRC; NOAA will provide the primary U.S. support to sustain the IPRC server infrastructure over the long term (in cooperation with Japan). In addition to improving initializations for seasonal forecasting at NCEP, NOAA will implement sustained ocean data assimilation activities at GFDL to enable experimental decadal forecasts, provide ocean initial conditions for IPCC type scenarios, monitor ocean heat uptake, monitor the thermohaline circulation for abrupt changes, and develop a capability for monitoring changes in oceanic carbon sources and sinks.

6.12.4 Summary: This task will support climate services by providing the integrating data, synthesis, and analysis infrastructure for the ocean and atmosphere measurements, both *in situ* and space based, needed to: 1) document long-term trends in sea level change; 2) document heat uptake, transport, and release by the ocean; 3) document ocean carbon sources and sinks; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

| | NOAA Contributions | | | | | | | | International Goal |
|--------------------------|--------------------|------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | |
| Data set development | X | X | X | X | X | X | X | X | X |
| World Ocean Database | | | | X | X | X | X | X | X |
| Standards and protocols | | | X | X | X | X | X | X | |
| Systems interoperability | X | X | X | X | X | X | X | X | X |

| | | | | | | | | | |
|----------------------------------|---|---|---|---|---|---|---|---|---|
| Automated monitoring tools | X | X | X | X | X | X | X | X | X |
| IPRC server | X | X | X | X | X | X | X | X | X |
| GODAE pilot activities (JIMO) | X | X | X | X | X | X | X | X | X |
| Operationalize GODAE pilot | | X | X | X | X | X | X | X | X |
| Global initialization for S-I | X | X | X | X | X | X | X | X | X |
| Experimental decadal forecast | | X | X | X | X | X | X | X | X |
| Conditions for IPCC scenarios | | X | X | X | X | X | X | X | X |
| Monitor ocean heat uptake | | X | X | X | X | X | X | X | X |
| Monitor thermohaline circulation | | | | X | X | X | X | X | X |
| Monitor carbon sources and sinks | X | X | X | X | X | X | X | X | X |
| Argos data processing – | | | | | | | | | |
| Drifting Buoy arrays | X | X | X | X | X | X | X | X | X |
| Argos data processing – | | | | | | | | | |
| Tropical Moored Buoy network | X | X | X | X | X | X | X | X | X |
| Argos data processing – | | | | | | | | | |
| Ocean Ref stations | X | X | X | X | X | X | X | X | X |

7.0 Management Plan – System organization and product delivery

A global effort of the proposed magnitude must be integrated, organized, and managed as a system in order to be effective. Matrix management is NOAA’s corporate business practice and standard protocol. This management plan will follow that protocol by capitalizing on the capabilities that presently exist across the agency while building toward the vision of a single composite system.

Implementation of the individual *in situ* networks will continue to be through distributed centers of expertise at the NOAA Research laboratories, the National Ocean Service Center for Operational Oceanographic Products and Services, the National Data Buoy Center, and the university laboratories that have developed the instruments and techniques. The space components and data management will be centered in the NOAA Satellite and Information Service. The focal point for developing global ocean data assimilation capabilities will be the Geophysical Fluid Dynamics Laboratory in partnership with the National Centers for Environmental Prediction and university-based applied research centers.

To weld the distributed efforts together into the single vision, NOAA has established a project Office of Climate Observation (OCO) under the auspices of the NOAA Climate Program. Organizationally the project office is located within the Office of Global Programs (OGP). OGP embodies a global perspective and is experienced in matrix management. One of OGP’s four strategic objectives is “development of the *in situ* ocean component of the global climate observing system.” Additionally, for the climate observing system institutional mechanisms must be put in place to ensure continuous and close involvement of the research community. Research, operations, and management are inseparable for climate observation and OGP will hard-wire that relationship.

The Director of OGP utilizing the OCO is charged with advancing NOAA’s multi-year program plan for *Building a Sustained Ocean Observing System for Climate*. The OCO is a hybrid combining the functions of a traditional program office with the functions of a

center for system monitoring, evaluation, integration, and action. The individual network managers will continue to monitor and evaluate the performance of their individual networks, while the OCO will build the capability to monitor and evaluate the performance of the system as a whole, and take action to evolve the *in situ* networks for overall effectiveness and efficiency in meeting climate observation objectives.

The OCO is the management focus for the distributed ocean network operations and, utilizing the NOAA Observing System Architecture, establishes and maintains operational linkages between the networks and NOAA's other *in situ* and satellite elements and the data and modeling activities that are essential components of climate observation. The office provides a central point of contact within NOAA for coordination with the other agencies and nations involved in observing system implementation. The office receives and acts on feedback from the observing system customers - the operational forecast centers, international research programs, and major scientific assessments - and acts on their observational requirements in accordance with the NOAA Requirements-Based Management Process.

7.1 Subtask 1 – System Monitoring: The OCO monitors the status of the globally distributed networks to anticipate gaps and overlaps in their combined capabilities. Real-time reports from all platforms are being centralized so that up-to-date status can be displayed at all times. The office is working to report system statistics and metrics, routinely and on demand.

7.2 Subtask 2 – Evaluation: An team of expert scientists both internal and external to NOAA is being established to continually evaluate the effectiveness of the networks in meeting the performance measures and the adequacy of the deliverables in meeting the system objectives. The team of experts will evaluate analysis/synthesis products, recommend product improvements, recommend where additional sampling is needed or redundancies are not needed, recommend better utilization of existing and new *in situ* and satellite data, and assess the impacts of proposed changes to the system.

7.3 Subtask 3 – Action: System monitoring and evaluation will be useless unless there is responsive action taken to build the system, fix problems, and improve sampling strategies. Decisions must be made to implement the best solutions to conflicting requirements (multiple partners and customers have differing missions and will inevitably have differing requirements), to re-deploy existing resources to best improve the system, to select the highest priorities for system extensions and funding of new ideas, and to agree on quid pro quo with interagency and international partners. The OCO is charged with advancing NOAA's multi-year program plan and with evolving the system for maximum effectiveness and efficiency along the way.

7.4 Subtask 4 – Intra-agency, Interagency, and International Coordination: National and international coordination is essential to success in building the global ocean observing system for climate. The OCO is charged with building the infrastructure necessary to organize NOAA's ocean observing efforts along three axes – 1) climate services, 2) the U.S. Integrated Ocean Observing System, and 3) international implementation.

- 1) For climate services the ocean observations must be available to be combined with data from the atmospheric networks, land surface networks, and cryosphere networks. The requirements from the three user communities – the forecast centers, research programs, and scientific assessments – must be received and synthesized into common requirements or prioritized if they do not resolve readily.
- 2) For the U.S. Integrated Ocean Observing System, NOAA's climate system will make a significant contribution to the global component where like data from the various platforms, *in situ* and space-based, must be combined to form complete fields (e.g., sea surface temperature from ships, drifting and moored buoys, and satellites). NOAA's efforts must be combined with the efforts of the other NOPP agencies into a seamless system.
- 3) For international implementation NOAA must work with the implementation panels of the Joint IOC/WMO Commission for Oceanography and Marine Meteorology (JCOMM) to ensure that consistent standards and formats are used by all participating nations so that data can be easily shared and that consistent quality can be expected from all platforms regardless of their national origin.

In addition to dedicated infrastructure needed for NOAA to operate an office for climate observation, dedicated infrastructure is also needed for operation of the interagency and intergovernmental planning and implementation coordination organizations. These interagency/international organizations rely on funding from the member agencies for their support. NOAA has historically provided a significant portion of the funding needed to maintain the existing international secretariats, science and implementation panels, and capacity building efforts of GOOS, GCOS, and the JCOMM. This funding support has been ad hoc and in general from the research programs. As a central component of sustaining the long-term, operational global climate observing system, support for the national/international coordination/implementation infrastructure will be institutionalized via the OCO.

7.5 Subtask 5 – Annual Report on the Ocean's Role in Climate: The organizing framework to bring the multiple elements of the composite ocean observing system together is the routine delivery of an *Annual Report on the State of the Ocean and the Ocean Observing System for Climate*. The National Climate Change Science Program strategic plan has identified the critical need for regular reports documenting the present state of the climate system components. NOAA's Office of Climate Observation is leading the national effort to develop this reporting for the ocean component. The theme of the report is the CCSP overarching question for guiding climate observations and monitoring- "What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize and validate models for prediction or long term projections?"

The annual report synthesizes satellite and *in situ* observations integrated with models and provides the products to decision makers, the science community, and the public. This reporting framework also establishes a formal mechanism for implementing a "user-

driven” observing system and for reporting on the system’s performance in meeting the requirements of the operational forecast centers, international research programs, and major scientific assessments. Stakeholders are invited to provide formal recommendations for system improvement and evolution as part of the annual report process.

The annual report contains four chapters:

- 1) This chapter describes The Role of the Ocean in Climate and includes a description of ENSO, SST, sea ice, and sea level, and the various demands on the system incorporating seasonal, interannual, decadal, and climate change time scales. This chapter sets the context for the report and outlines common themes, including the significance of the global ocean observing system and the demands on the system.
- 2) The second chapter documents the State of the Ocean. The target audience is decision makers and non-scientists. This chapter is written by the experts in the field and is an annually updated climatology of the ocean, placed in historical context, with discussion of the present uncertainties and with pointers to products of greater detail and climate applications.
- 3) The third chapter documents the State of the Observing System. The target audience is NOAA management. This chapter has two sections:
 - a) System Progress in meeting milestones is documented by the network managers for their projects and by the OCO for the system in total. Annual statistics and status are given.
 - b) Work plans for the next fiscal year include future efforts.
- 4) Chapter four recaps the State of the Science. The target audience is scientists. The final chapter of the report contains a bibliography of refereed publications from scientific journals treating the global observation of ocean heat, carbon, fresh water, and sea level change. Each year a selected number of abstracts of particularly relevant scientific papers are published with the report.

7.6 Subtask 6 – External Review: The execution of this plan will be subject to normal management review in accordance with NOAA’s Requirements-Based Management Process. Additionally, for specific programmatic advice and guidance, the Climate Observing System Council (COSC) has been established to review the program’s contribution to the international Global Climate Observing System and to recommend effective ways for the program to respond to the long-term observational needs of the operational forecast centers, international research programs, and major scientific assessments. The Council is comprised of members both internal and external to NOAA who individually offer their expert advice; the Council is not expected to develop consensus opinions. The term of membership is two years with a renewal option for two additional terms. The Council meets at least annually to:

- Advise the OCO on priorities for sustaining and enhancing components of the global climate observing system.
- Review the accomplishments and future plans of specific program activities.

- Recommend realignment of activities, or entirely new activities, within the program as appropriate to satisfy the evolving requirements for climate observation.
- Bring to the OCO a broad view on national and international climate research and operational activities and their implications.
- Provide coordinating linkages with national and international programs requiring and/or contributing to the implementation of the global climate observing system.
- Advise the OCO on the balance of activities within the program in the context of NOAA's overarching climate service requirements, of other national and international requirements, and of other national and international contributions to the global climate observing system.

7.7 System management and product delivery milestones:

| | NOAA Contributions | | | | | | | International Goal |
|---------------------------------------|--------------------|------|------|------|------|------|------|--------------------|
| | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 |
| System Monitoring | X | X | X | X | X | X | X | X |
| System Evaluation: | | | | | | | | |
| Seasonal forecasting | | X | X | X | X | X | X | X |
| Decadal forecasting | | X | X | X | X | X | X | X |
| Climate change | | | | X | X | X | X | X |
| Sea level change | | X | X | X | X | X | X | X |
| Carbon sources and sinks | | | | | | | | X |
| Air-sea exchange,heat/water | | X | X | X | X | X | X | X |
| Heat storage/thermohaline circulation | X | | X | X | X | X | X | X |
| SST | X | X | X | X | X | X | X | X |
| Sea Ice | | X | X | X | X | X | X | X |
| Interagency/International panels | X | X | X | X | X | X | X | X |
| International capacity building | | | | X | X | X | X | X |
| Transition SST eval res to ops | X | X | X | X | X | X | X | X |
| Mgmt – wkshps & science mtgs | X | X | X | X | X | X | X | X |
| Mgmt – administration & finance | | X | X | X | X | X | X | X |
| Mmgt ops funded from research | X | X | X | X | X | X | X | X |
| Annual Report | | X | X | X | X | X | X | X |
| External review | | | X | X | X | X | X | |

8.0 Education

The NOAA Office of Climate Observation sponsors three educational initiatives:

- 1) Teacher at Sea Program – OCO sponsors one or two teachers each year to participate in ocean research on board NOAA and other research vessels.
- 2) Adopt a Drifter Program – OCO established this program in December 2004 to enable K-16 teachers and their students to adopt a drifting buoy by partnering with an international school. They can follow their buoy's movement across the ocean by using an Adopt a Drifter Program website.
- 3) OCO is launching a student internship program to enrich students' understanding of and appreciation for NOAA and observing system science, and to provide additional support for OCO office projects.

A summary of the sampling requirements for the global ocean, based largely on OOSDP (1995), but with revisions as appropriate. These are a statement of the required measurement network characteristics, not the characteristics of the derived field. The field estimates must factor in geophysical noise and unsampled signal. Some projections (largely unverified) have been included for GODAE.

| Sampling Requirements for the Global Ocean | | | | | | | |
|--|------------------------------------|-------------------------------|--|--------------------|---------------|----------|---|
| Code | Application | Variable | Hor. Res. | Vert. Res. | Time Res. | #samples | Accuracy |
| A | NWP, climate, mesoscale ocean | Remote SST | 10 km | - | 6 hours | 1 | 0.1-0.3°C |
| B | Bias correction, trends | <i>In situ</i> SST | 500 km | - | 1 week | 25 | 0.2-0.5°C |
| C | Climate variability | Sea surface salinity | 200 km | - | 10 day | 1 | 0.1 |
| D | Climate prediction and variability | Surface wind | 2° | - | 1-2 day | 1-4 | 0.5-1 m/s in components |
| E | Mesoscale, coastal | Surface wind | 50 km | - | 1 day | 1 | 1-2 m/s |
| F | Climate | Heat flux | 2° x 5° | - | month | 50 | Net: 10 W/m ² |
| G | Climate | Precip. | 2° x 5° | - | daily | Several | 5 cm/month |
| H | Climate change trends | Sea level | 30-50 gauges + GPS with altimetry, or several 100 gauges + GPS | - | monthly means | | 1 cm, giving 0.1 mm/yr accuracy trends over 1-2 decades |
| I | Climate variability | Sea level anomalies | 100-200 km | - | 10-30 days | ~ 10 | 2 cm |
| J | Mesoscale variability | Sea level anomalies | 25-50 km | - | 2 days | 1 | 2-4 cm |
| K | Climate, short-range prediction | sea ice extent, concentration | ~ 30 km | - | 1 day | 1 | 10-30 km 2-5% |
| L | Climate, short-range prediction | sea ice velocity | ~ 200 km | - | Daily | 1 | ~ cm/s |
| M | Climate | sea ice volume, thickness | 500 km | - | monthly | 1 | ~ 30 cm |
| N | Climate | surface pCO ₂ | 25-100 km | - | daily | 1 | 0.2-0.3 µatm |
| O | ENSO prediction | T(z) | 1.5° x 15° | 15 m over 500 m | 5 days | 4 | 0.2°C |
| P | Climate variability | T(z) | 1.5° x 5° | ~ 5 vertical modes | 1 month | 1 | 0.2°C |
| Q | Mesoscale ocean | T(z) | 50 km | ~ 5 modes | 10 days | 1 | 0.2°C |
| R | Climate | S(z) | large-scale | ~ 30 m | monthly | 1 | 0.01 |
| S | Climate, short-range prediction | U(surface) | 600 km | - | month | 1 | 2 cm/s |
| T | Climate model valid. | U(z) | a few places | 30 m | monthly means | 30 | 2 cm/s |

Table 1. From *The Action Plan for GOOS/GCOS and Sustained Observation for CLIVAR* by Needler et al. -- *OCEANOBS 99*

Appendix A

Foundation Documents

Observing the Oceans in the 21st Century, edited by Chester J. Koblinsky and Neville R. Smith, 2001, GODAE Project Office, Bureau of Meteorology, Melbourne, Australia, ISBN 0642 70618 2.

OCEANOBS 99, proceedings of the International Conference on the Ocean Observing System for Climate, GCOS/GOOS/WCRP Ocean Observations Panel for Climate and the CLIVAR Upper Ocean Panel, Saint-Raphael, France, October 1999.

International Sea Level Workshop Report, GCOS/GOOS/WCRP Ocean Observations Panel for Climate and the CLIVAR Upper Ocean Panel, April 1998, GCOS #43, GOOS #55, ICPO #16.

A Large Scale CO₂ Observing Plan: In Situ Oceans and Atmosphere (LSCOP), a contribution to the implementation of the U.S. Carbon Cycle Science Plan by the *In situ* Large-Scale CO₂ Observations Working Group, April 2002.

Implementation Plan for the Global Observing System for Climate in support of the UNFCCC (GCOS-92), the Global Climate Observing System, October 2004, GCOS #92, WMO/TD #1219.

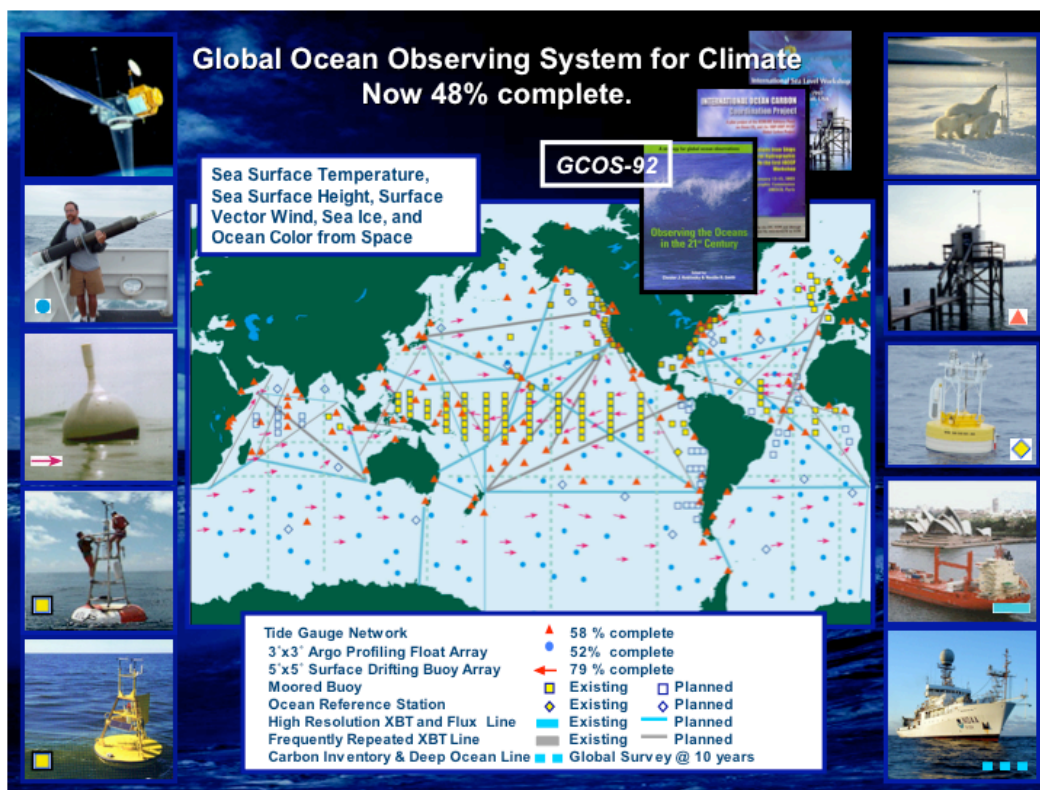


Figure 1

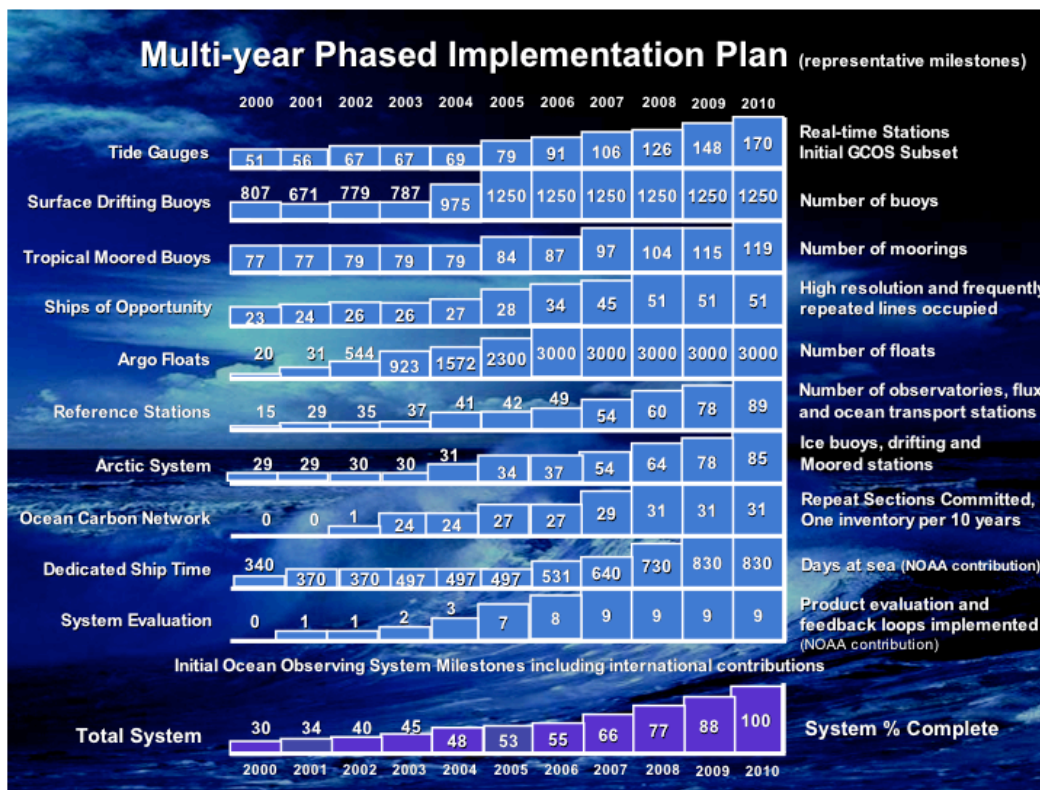


Figure 2

| | | Table 2 | | | Program Baseline Assessment | | | | | |
|---|--|---|------|-------|-----------------------------|-------|-------|-------|-------|-----------------|
| | | Climate Observation Program – Ocean Component (\$ millions) | | | | | | | | |
| | | FY04 | FY05 | FY 06 | FY 07 | FY 08 | FY 09 | FY 10 | FY 11 | Interntl Goal** |
| REQUIREMENT INPUT | | | | | | | | | | |
| Capability A: Extend ocean network to achieve global coverage | | | | | | | | | | |
| Capacity (Tide Gauge Network) | | | | | | | | | | |
| Indo-Pacific network stations | | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 |
| Cost | | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | |
| Station upgrades | | 4 | 10 | 16 | 26 | 32 | 32 | 32 | 32 | 199 |
| Cost | | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | |
| GPS stations | | 10 | 14 | 18 | 40 | 40 | 40 | 40 | 40 | 86 |
| Cost | | 0.1 | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | |
| GPS data processing | | | x | x | x | x | x | x | x | x |
| Cost | | 0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | |
| Atlantic research network stations | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition Atlantic stations from research to ops | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 |
| Cost | | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | |
| Reference stations | | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 62 |
| Cost (\$0.5 m) Commerce and Transportation | | | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | |
| Climate analysis | | | x | x | x | x | x | x | x | x |
| Cost | | 0 | 0.1 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | |
| Technology development | | | | x | x | x | x | x | x | x |
| Cost | | 0 | 0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | |
| Federal FTEs* | | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | | |
| non-Federal FTEs* | | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | |
| Cost | | | | | | | | | | |
| Total | | 1.0 | 1.8 | 1.8 | 2.4 | 2.8 | 3.0 | 3.0 | 3.0 | |
| % complete | | 33 | 60 | 60 | 80 | 93 | 100 | 100 | 100 | |
| Capacity (Drifting Buoy Array) | | | | | | | | | | |
| Global array operations buoys | | 670 | 840 | 840 | 840 | 840 | 840 | 840 | 840 | 1250 |
| Cost | | 1.9 | 2.9 | 2.9 | 2.9 | 3.0 | 3.0 | 3.0 | 3.0 | |
| Research buoys | | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research contributions to operations | | 0 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 0 |
| Cost | | 0 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | |
| Add met sensors/barometers | | 40 | 80 | 80 | 200 | 500 | 600 | 670 | 670 | 1250 |
| Cost | | 0 | 0.2 | 0.2 | 0.5 | 1.0 | 2.0 | 2.8 | 2.8 | |
| Technology development | | | x | x | x | x | x | x | x | x |
| Cost | | 0 | 0.1 | 0.1 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Federal FTEs | | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | | |
| non-Federal FTEs | | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | |
| Cost | | | | | | | | | | |
| Total | | 2.7 | 4.0 | 4.0 | 4.6 | 5.3 | 6.3 | 7.1 | 7.1 | |
| % complete | | 38 | 56 | 56 | 65 | 75 | 89 | 100 | 100 | |
| Capacity (Tropical Moored Buoy Network) | | | | | | | | | | |
| TAO/TRITON operations buoys | | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 69 |
| Cost | | 2.6 | 2.6 | 2.6 | 3.0 | 3.1 | 3.1 | 3.1 | 3.1 | |
| Indian Ocean expansion | | 0 | 3 | 5 | 7 | 15 | 15 | 15 | 15 | 30 |
| Cost | | 0.4 | 0.7 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | |
| PIRATA operations | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cost | | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | |
| Atlantic Ocean expansions | | 0 | 0 | 4 | 4 | 6 | 9 | 9 | 9 | 9 |
| Cost | | 0 | 0 | 0.6 | 0.6 | 1.0 | 1.0 | 1.0 | 1.0 | |
| System upgrades | | 0 | 0 | 30 | 65 | 65 | 65 | 65 | 65 | |
| Cost | | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Add salinity sensors | | 10 | 10 | 55 | 65 | 65 | 65 | 65 | 65 | 99 |
| Cost | | 0 | 0 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | |
| Add flux capability (as per Ocean Ref Station plan) | | 0 | 0 | 7 | 7 | 7 | 7 | 7 | 7 | 8 |
| Cost | | 0.0 | 0 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | |
| Technology development | | | | x | x | x | x | x | x | |
| Cost | | 0.0 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | |
| PMEL Operations | | x | x | x | x | x | x | x | x | x |
| Cost | | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Federal FTEs | | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | |
| Cost | | | | | | | | | | |

| Table 2 Program Baseline Assessment | | | | | | | | | |
|---|----------|----------|----------|----------|-------|----------|----------|----------|-----------------------------|
| Climate Observation Program – Ocean Component (\$ millions) | | | | | | | | | |
| 100% Requirement | | | | | | | | | Intern ational Goal** |
| | FY 04 | FY 05 | FY 06 | FY 07 | FY 08 | FY 09 | FY 10 | FY 11 | |
| non-Federal FTEs | 9 | 10 | 16 | 16 | 16 | 16 | 16 | 16 | |
| Cost | | | | | | | | | |
| Total | 4.0 | 4.8 | 8.0 | 8.5 | 9.1 | 9.2 | 9.2 | 9.2 | |
| % complete | 43 | 52 | 87 | 92 | 99 | 100 | 100 | 100 | |
| Capacity (Ships of Opportunity Network) | | | | | | | | | |
| Ships-of-Opportunity operations (including 10,000 XBTs) | 2 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 20 |
| Cost | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.1 | 1.1 | 1.1 | |
| Complete high resolution network | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Cost | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Complete frequently repeated network | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 21 |
| Cost | 0 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | |
| HRX research lines & sensor R & D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research lines to operations | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 |
| Cost | 1.1 | 1.1 | 1.1 | 1.1 | 1.2 | 1.2 | 1.4 | 1.4 | |
| Transition NSF lines from research to operations | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | |
| Cost | 0.2 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Add flux capability and salinity to high resolution network | 2 | 7 | 12 | 15 | 15 | 15 | 15 | 15 | 21 |
| Cost | 0 | 0 | 0.0 | 0.5 | 1.0 | 2.5 | 4.7 | 4.7 | |
| AOML ship and drifter operations | x | x | x | x | x | x | x | x | |
| Cost | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | |
| Add automated met package to 200 VOSclim ships (accounting in Local Forecasts and Warnings) | 0 | 1 | 1 | 100 | 200 | 200 | 200 | 200 | 200 |
| Cost | 0.0 | 0.1 | 0.1 | [1.6] | [1.6] | [1.6] | [1.6] | [1.6] | |
| Technology development | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | |
| Federal FTEs | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 6 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | |
| Cost | | | | | | | | | |
| Total | 3.9 | 4.6 | 4.6 | 5.2 | 6.1 | 7.9 | 10.3 | 10.3 | |
| % complete | 38 | 45 | 45 | 50 | 59 | 77 | 100 | 100 | |
| Capacity (Argo Array) | | | | | | | | | |
| Global operations of floats | 750 | 1150 | 1485 | 1485 | 1385 | 1385 | 1385 | 1385 | 2800 |
| Cost | 10.1 | 10.1 | 10.1 | 10.1 | 10.1 | 10.1 | 10.1 | 10.1 | |
| Research array of floats | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Glider development | 3 | 10 | 20 | 50 | 100 | 100 | 100 | 100 | 200 |
| Cost | 0.3 | 0.3 | 0.3 | 1.0 | 2.0 | 4.0 | 5.0 | 5.0 | |
| Technology development | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | |
| Federal FTEs | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | |
| Cost | | | | | | | | | |
| Total | 10.4 | 10.4 | 10.4 | 11.4 | 12.4 | 14.4 | 15.4 | 15.4 | |
| % complete | 68 | 68 | 68 | 74 | 81 | 94 | 100 | 100 | |
| Capacity (Ocean Reference Stations) | | | | | | | | | |

| | | | | | | | | | |
|--|------------|------------|------------|------------|------------|-------------|-------------|-------------|-----|
| Operational flux moorings | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 29 |
| Cost | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | |
| Research flux moorings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research moorings to operations | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Cost | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | |
| Climate sensors on NSF OOI stations | 0 | 0 | 0 | 3 | 5 | 8 | 10 | 10 | 42 |
| Cost | 0 | 0 | 0.0 | 0.6 | 1.0 | 1.6 | 2.0 | 2.0 | |
| Establish Transport monitoring network | 0 | 1 | 1 | 2 | 3 | 5 | 6 | 6 | 10 |
| Cost | 0 | 0.4 | 0.4 | 0.8 | 1.2 | 2.0 | 2.5 | 2.5 | |
| Research transport monitoring | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research to operational transport monitoring | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 |
| Cost | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Enhance flux data assembly center for ocean reference | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | |
| Establish reference fleet standard intercomparison | x | x | x | x | x | x | x | x | x |
| Cost | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Pacific Rain gauge network - PACRAIN | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Cost | 0.3 | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Research rain gauge network | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Research Antarctic arrays (Weddell Sea) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research Antarctic arrays to operations | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Cost | 0 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | |
| Establish sinking region monitoring | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 4 | 5 |
| Cost | 0 | 0 | 0.0 | 0.7 | 1.4 | 2.4 | 2.4 | 2.4 | |
| Southern hemisphere thermohaline monitoring sections | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 3 |
| Cost | 0 | 0 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 3.0 | |
| Technology development | | | | | | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | |
| Federal FTEs | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 9 | 10 | 10 | 15 | 21 | 27 | 32 | 32 | |
| Cost | | | | | | | | | |
| Total | 2.8 | 3.7 | 3.7 | 6.1 | 8.8 | 12.9 | 14.9 | 14.9 | |
| % complete | 19 | 25 | 25 | 41 | 59 | 87 | 100 | 100 | |
| Capacity (Coastal Moorings): provided by Goal 3, Weather and Water, Local Forecasts and Warnings, National Data Buoy Center | | | | | | | | | |
| Upgrade climate subset with ocean sensors (65 stations) | 0 | 0 | 0 | 65 | 65 | 65 | 65 | 65 | 105 |
| Cost | | | | | | | | | |
| Technology development | | | | x | x | x | x | x | x |
| Cost | | | | | | | | | |
| Federal FTEs | | | | | | | | | |
| Cost | | | | | | | | | |
| non-Federal FTEs | | | | | | | | | |
| Cost | | | | | | | | | |
| Total | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| % complete | | | | | | | | | |
| Capacity (Ocean Carbon) | | | | | | | | | |
| Global inventory survey | 6 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 25 |
| Cost | 1 | 1.5 | 1.5 | 1.7 | 2.0 | 3.0 | 3.3 | 3.3 | |
| Time series moorings | 3 | 4 | 4 | 5 | 6 | 7 | 8 | 8 | 12 |
| Cost | 0.1 | 0.4 | 0.4 | 0.8 | 1.5 | 1.5 | 2.0 | 2.0 | |
| Coastal flux moorings | 0 | 0 | 0 | 2 | 5 | 8 | 11 | 11 | 29 |
| Cost | 0 | 0 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.0 | |
| Flux on ships of opportunity | 7 | 7 | 7 | 8 | 8 | 12 | 12 | 12 | 21 |
| Cost | 1.3 | 1.3 | 1.3 | 1.5 | 1.5 | 1.8 | 2.1 | 2.1 | |
| Research flux on moorings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | |
|--|------------|------------|------------|------------|------------|-------------|-------------|-------------|---|
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Transition research flux moorings to operations | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 |
| Cost | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Satellite data, ocean color | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | x |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Data management | x | x | x | x | x | x | x | x | x |
| Cost | 0.2 | 0.5 | 0.5 | 0.8 | 1.2 | 1.4 | 1.8 | 1.8 | |
| Technology development | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Federal FTEs | 6 | 6 | 6 | 7 | 8 | 8 | 8 | 8 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 2 | 6 | 6 | 10 | 14 | 20 | 26 | 26 | |
| Cost | | | | | | | | | |
| Total | 2.9 | 4.0 | 4.0 | 6.1 | 8.1 | 10.1 | 12.1 | 12.1 | |
| % complete | 24 | 33 | 33 | 50 | 67 | 83 | 100 | 100 | |
| | | | | | | | | | |
| Capacity (Data and Assimilation Sub-Systems) | | | | | | | | | |
| Data set development (COSP NODC/NCDC 346K) | | | | | x | x | x | x | x |
| Cost | 0.3 | 0.3 | 0.3 | 0.4 | 0.8 | 1.5 | 2.0 | 2.0 | |
| World Ocean Database | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.3 | 0.6 | 0.8 | 1.1 | 1.1 | |
| Standards and protocols | | | x | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Systems interoperability | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | |
| Transition research interoperability to operations | | | | | | | | | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Automated monitoring tools | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | |
| IPRC server (.5 IPRC, .2 global, .1 data interoperability) | | | | | | | | | x |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| GODAE pilot activities (JIMO) | x | x | x | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Operationalize GODAE pilot activities | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.3 | 0.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | |
| Global initialization for S-I forecasting (COSP) | x | | | | | | | | x |
| Cost (0.5 to NCEP) | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Experimental decadal forecasting (COSP) | x | | | | | | | | x |
| Cost (212 to GFDL) | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Altimetry (COSP 240 K) | | | | x | x | x | x | x | x |
| Cost | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.8 | 1.0 | 1.0 | |
| Monitor ocean heat uptake | | | | x | x | x | x | x | x |
| Cost | 0 | 0.7 | 0.7 | 0.9 | 0.9 | 1.1 | 1.3 | 1.3 | |
| Monitor thermohaline circulation | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.2 | 0.2 | 0.4 | 0.6 | 0.6 | |
| Monitor carbon sources and sinks | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 | |
| Argos data processing - Drifting Buoy Arrays | x | x | x | x | x | x | x | x | x |
| Cost | 0.6 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | |
| Argos data processing - Tropical Moored Buoy network | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | |
| Argos data processing - Ocean Reference Stations | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | |
| Federal FTEs | 4 | 4 | 4 | 6 | 8 | 8 | 8 | 8 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 9 | 12 | 12 | 20 | 25 | 30 | 36 | 36 | |
| Cost | | | | | | | | | |
| Total | 2.7 | 3.9 | 3.9 | 7.5 | 8.2 | 10.6 | 12.1 | 12.1 | |
| % complete | 22 | 32 | 32 | 62 | 68 | 88 | 100 | 100 | |
| | | | | | | | | | |
| Capacity (Management and Product Delivery) | | | | | | | | | |
| System monitoring | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | |
| System evaluation | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |

| | | | | | | | | | |
|---|------------|------------|------------|------------|------------|------------|------------|------------|-----|
| SST | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.5 | |
| Sea level change | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Carbon sources and sinks | | | | | | | | | x |
| Cost | 0 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Ocean storage, transport, heat and water | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Air-sea flux, heat, water | x | x | x | x | x | x | x | x | x |
| Cost | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 | |
| Seasonal forecasting | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.5 | 0.5 | |
| Decadal forecasting | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.2 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | |
| Climate change | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.2 | 0.2 | 0.4 | 0.5 | 0.5 | |
| Transition SST evaluation from research to operations | | | | | | | | | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Management -- workshops and science meetings | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | |
| Management -- administration and finance | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Improved Predictions PACS-GAPP (old PACS \$) | x | x | x | x | x | x | x | x | x |
| Cost | 1 | 1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Annual Report | x | x | x | x | x | x | x | x | x |
| Cost | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | |
| International science and implementation panels | x | x | x | x | x | x | x | x | x |
| Cost | 0.3 | 0.4 | 0.4 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | |
| International panels, transition funding from research to ops | | | | | | | | | 0 |
| Cost | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Capacity building | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.3 | 0.3 | 0.5 | 1.0 | 1.0 | |
| External review panel expenses | | | | x | x | x | x | x | x |
| Cost | 0 | 0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | |
| Action -- system manager's contingency fund | | x | x | x | x | x | x | x | x |
| Cost | 0 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Federal FTEs | 5 | 10 | 10 | 12 | 13 | 14 | 15 | 15 | |
| Cost | | | | | | | | | |
| non-Federal FTEs | 4 | 8 | 8 | 10 | 11 | 14 | 16 | 16 | |
| Cost | | | | | | | | | |
| Total | 2.5 | 4.5 | 4.5 | 6.5 | 6.9 | 8.2 | 9.5 | 9.5 | |
| % complete | 26 | 47 | 47 | 68 | 73 | 86 | 100 | 100 | |
| Capacity (Dedicated Ship Time) days at sea | | | | | | | | | |
| Carbon and deep ocean surveys | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 240 |
| Cost | [1.9] | [1.9] | | | | | | | |
| Coastal, Flux maps and deep ocean surveys | 0 | 0 | 0 | 20 | 20 | 40 | 40 | 40 | 240 |
| Cost | 0 | 0 | 0.0 | 0.4 | 0.4 | 0.9 | 0.9 | 0.9 | |
| Ka'imimoana | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 276 |
| Cost | [5.2] | [5.2] | [5.2] | [5.2] | [5.2] | [5.2] | [5.2] | [5.2] | |
| TAO/TRITON | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 90 |
| Cost | [1.4] | [1.4] | | | | 0.9 | 0.9 | 0.9 | |
| PIRATA | 0 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 124 |
| Cost | 0.1 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | |
| Reference Stations | 47 | 47 | 47 | 47 | 57 | 57 | 57 | 57 | 480 |
| Cost | [1.0] | [1.0] | 0.0 | 0.0 | 0.6 | 1.3 | 1.3 | 1.3 | |
| Deployment of drifting arrays | 0 | 10 | 10 | 60 | 60 | 120 | 120 | 120 | 100 |
| Cost | 0.0 | 0.5 | 0.5 | 1.3 | 1.3 | 2.6 | 2.6 | 2.6 | |
| Thermohaline Circulation Monitoring | 26 | 26 | 26 | 90 | 90 | 170 | 170 | 170 | 340 |
| Cost | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.0 | 4.4 | 4.4 | |
| Process Research | | | 56 | 230 | 230 | 230 | 230 | 230 | |
| Cost | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|--|------------------|--|---------|-----|-----|-----|-----|------|------|------|------|-----|
| Arctic Hydrographic Sections | | | | | 0 | 0 | 0 | 60 | 60 | 60 | 60 | 60 | 120 |
| Cost | | | | | 0.0 | 0.0 | 0.0 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | |
| Federal FTEs (Ship time) | | | | | 63 | 63 | 63 | 64 | 67 | 67 | 67 | 67 | |
| Cost | | | | | | | | | | | | | |
| non-Federal FTEs | | | | | | | | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | | | | | |
| | | | | Total I | 0.1 | 1.1 | 1.1 | 3.6 | 5.2 | 9.6 | 12.0 | 12.0 | |
| % complete | | | | | 1 | 9 | 9 | 30 | 44 | 80 | 100 | 100 | |
| | | Total ship days: | | | 422 | 466 | 466 | 660 | 670 | 830 | 830 | 830 | |
| Capacity (Integrated Arctic Ocean Observing System) | | | | | | | | | | | | | |
| Arctic Ocean pathway moorings | | | | | 0 | 0 | 0 | 1 | 3 | 8 | 8 | 8 | 12 |
| Cost | | | | | 0 | 0 | 0.0 | 0.7 | 1.5 | 2.0 | 4.0 | 4.0 | |
| Arctic Ice Mass and (in '07) Upper Ocean drifters | | | | | 3 | 3 | 3 | 3 | 5 | 6 | 8 | 8 | 12 |
| Cost | | | | | 0.3 | 0.3 | 0.3 | 0.5 | 2.5 | 3.0 | 4.0 | 4.0 | |
| Arctic Ocean gateway mooring sets (ASOF) | | | | | 1 | 1 | 1 | 2 | 3 | 4 | 4 | 4 | 8 |
| Cost | | | | | 0.2 | 0.2 | 0.2 | 0.6 | 0.9 | 1.2 | 1.2 | 1.2 | |
| Arctic Ocean automated drifting stations | | | | | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 3 | 3 |
| Cost | | | | | 0 | 0 | 0.0 | 0.8 | 1.6 | 2.4 | 2.4 | 2.4 | |
| Ice buoys (IABP) | | | | | 10 | 14 | 14 | 20 | 20 | 20 | 20 | 20 | 40 |
| Cost | | | | | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | |
| Arctic Ocean hydrographic sections | | | | | 0 | 0 | 0 | 1 | 2 | 4 | 6 | 6 | 12 |
| Cost | | | | | 0 | 0 | 0.0 | 1.0 | 2.0 | 4.0 | 6.0 | 6.0 | |
| Bering Sea hydrographic sections | | | | | 1 | 0 | 0 | 1 | 2 | 3 | 4 | 4 | 4 |
| Cost | | | | | 0.7 | 0 | 0.0 | 0.4 | 0.8 | 1.2 | 1.6 | 1.6 | |
| Bering Sea biophysical moorings | | | | | 1 | 1 | 1 | 1 | 4 | 4 | 6 | 6 | 6 |
| Cost | | | | | 0.3 | 0.3 | 0.3 | 0.3 | 0.6 | 0.6 | 0.9 | 0.9 | |
| Deep western boundary current section | | | | | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| Cost | | | | | 0 | 0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Deep western boundary current moorings | | | | | 0 | 0 | 0 | 0 | 3 | 4 | 4 | 4 | 4 |
| Cost | | | | | 0 | 0 | 0.0 | 0.0 | 0.4 | 0.5 | 0.5 | 0.5 | |
| Retrospective data sets rescued/created | | | | | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 6 |
| Cost | | | | | 0.2 | 0.2 | 0.2 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 | |
| Arctic Research Program Management | | | | | | | | | | | | | 1 |
| Cost | | | | | 0.2 | 0.2 | 0.2 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| Data analysis and assimilation | | | | | | | | | | | | | 4 |
| Cost | | | | | 0 | 0 | 0 | 0.8 | 1.6 | 2.1 | 2.1 | 2.1 | |
| Federal FTEs | | | | | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | |
| Cost | | | | | | | | | | | | | |
| non-Federal FTEs | | | | | 12 | 12 | 12 | 20 | 28 | 36 | 41 | 41 | |
| Cost | | | | | | | | | | | | | |
| Total | | | | | 2.1 | 1.4 | 1.4 | 6.4 | 13.5 | 18.6 | 24.3 | 24.3 | |
| % complete | | | | | 9 | 6 | 6 | 26 | 56 | 77 | 100 | 100 | |
| | | | | | | | | | | | | | |
| Capacity (Satellites) | | | | | | | | | | | | | |
| Real time data transmission | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Sea surface temperature | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Sea surface height | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Surface vector wind | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |
| % complete | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Capacity (Facilities) | | | | | | | | | | | | | |
| Lab | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Machine shop | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Warehouse | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Data assembly | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|--|--|--|--|-------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|--|
| Data archive | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Office space for 75 shore-based FTEs | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Operations center for system monitoring, evaluation, international coordination, and management | | | | | x | x | x | x | x | x | x | x | |
| Cost | | | | | 0 | 0.0 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Total | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | |
| % complete | | | | | | | | | | | | | |
| Capacity (Aircraft) | | | | | | | | | | | | | |
| Arctic buoy deployment - flight hours | | | | | 0 | 0 | 0 | 176 | 176 | 176 | 176 | 176 | |
| Cost | | | | | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | |
| Total | | | | | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | |
| % complete | | | | | | | | | | | | | |
| Capacity (HR Support) | | | | | | | | | | | | | |
| Cost | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |
| % complete | | | | | | | | | | | | | |
| Capacity (Institutional Overhead) | | | | | | | | | | | | | |
| Climate Office support | | | | | 0.8 | 2.2 | 2.2 | 3.2 | 4.3 | 5.5 | 6.6 | 6.6 | |
| OCO personnel & space | | | | | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 1.0 | |
| AOML personnel,space | | | | | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | |
| PMEL personnel,space | | | | | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | |
| Other (get to 6.6 CLIVAR) | | | | | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Subtotal | | | | | 5.6 | 6.2 | 6.2 | 7.2 | 8.4 | 9.6 | 10.8 | 10.8 | |
| GRAND TOTAL | | | | | 40.7 | 50.4 | 53.6 | 76.0 | 101.3 | 120.8 | 141.1 | 141.1 | |
| TOTAL Federal FTEs | | | | | 100 | 106 | 106 | 115 | 122 | 123 | 124 | 124 | |
| TOTAL non-Federal FTEs | | | | | 69 | 86 | 92 | 123 | 147 | 175 | 199 | 199 | |
| % complete - by dollars spent | | | | | 29 | 36 | 38 | 54 | 72 | 86 | 100 | 100 | |
| *All FTE costs are already included in displayed project costs | | | | | | | | | | | | | |
| **All spreadsheet figures represent the NOAA contribution toward the international goal shown in column N | | | | | | | | | | | | | |

APPENDIX C

Professional Development and Community Service by Scientists Funded by The Office of Climate Observation

**Professional Development and Community Service by Scientists funded by the
Office of Climate Observation**

Community Service (e.g., appointments to science and implementation panels)

Molly Baringer (NOAA/AOML)

AGU Ocean Science Secretary, 2002-present; Member NOAA/OAR ship time procurement procedure review panel; Associate Member IAPSO/SCOR Working Group 121 on Ocean Mixing.

Nicholas Bates (BBSR)

International Advisory Member of the European Carbo Ocean project.

Mark Bourassa (FSU)

NASA Ocean Vector Winds Science Team; NASA/OSU QuikSCAT mission; Next Vector Winds Mission Science Working Group; AMS Committee on Interaction of the Sea and Atmosphere.

John Bullister (NOAA/PMEL)

Served on WOCE Data Products committee.

Francisco Chavez (MBARI)

Member of NSF Geosciences Advisory committee (2003-2005); Member NSF Alan T. Waterman award committee (2003-2005); Member Advisory Board of the Instituto del Mar del Peru (IMARPE), the Peruvian fisheries and oceanography institute (2003-); Member Board of Directors of the Center for Integrated Marine Technologies (2002-); Member Board of Governors of Pacific Coastal Observing System (2003-); Member Science Team Global Ocean Timeseries (2002-); Member COCOA (Hyperspectral satellite coastal color imager) Science Team (2003-); Taught course on Coupled physical-biological and biogeochemical time series and advanced technologies at Universidad de Concepcion, Concepcion, Chile, January 20-24, 2003; Taught course on Coupled physical-biological and biogeochemical time series and advanced technologies at Instituto del Mar del Peru in Lima, Peru, January 27, 2003.

Steven K. Cook (NOAA/AOML)

WMO/IOC Ship Observations Team, Chairman – Ship of Opportunity Implementation Panel, Convener - Task Team on VOS Recruitment and Program Promotion; Task Team on VOS Automated Systems; Expert Group on Instrument Testing; WMO/IOC Data Buoy Cooperation Panel.

Bruce Cornuelle (SIO)

Serves on US GODAE SSC.

Meghan Cronin (NOAA/PMEL)

Co-organizer of “KESS and Beyond” science meeting at JAMSTEC, Yokohama, Japan, 5 June 2004; co-chair of U.S. CLIVAR PanAm panel; co-chair “Surface Fluxes” session at AMS 13th Conference on Interaction of the Sea and Atmosphere; co-organizer of NOAA PMEL colloquium series “Developing a North Pacific Observing System”; committee chair (advisor) for R. Wade, M.Sc. granted June 2004, University of Washington.

Yeun-Ho Chong Daneshzadeh (NOAA/AOML)

Global Temperature Salinity Profile Program committee.

Richard Feely (NOAA/PMEL)

Co-chair Repeat Hydrography CO₂/tracer Program Oversight Committee; Co-chair of NOAA Carbon Steering Committee; Member of International Ocean Carbon Coordination Project; Member of International Pacific CLIVAR Panel; Member of Carbon Cycle Science Program Science Steering Group; Team Member of the European CarboOcean; Member of PICES Working Group 17: Biogeochemical Data Integration and Synthesis; Member of U.S. SOLAS Steering Committee.

Silvia Garzoli (NOAA/AOML)

NOAA Experts Team to provide input to the interagency process developing a US Plan of Earth Observations; CLIVAR South Atlantic, Member of the Science Committee; GP Climate Goal 2 working group for Climate.

Gustavo Goni (NOAA/AOML)

NASA Ocean Surface Topography, Member of Science Team; NASA Panel Review for New Investigator Program in Earth Science.

Ed Harrison (NOAA/PMEL)

Chair, Ocean Observations Panel for Climate; Chair, OAR Climate Observing System Council; Co-Chair, US GODAE ST; US GOOS SC; Atmospheric Observation Panel for Climate; WCRP Working Group on Observations and Analysis; CLIVAR Global Synthesis and Observations Project; JCOMM Management Committee; Senior Fellow, JISAO; Senior Fellow, JIMAR.

Gregory Johnson (NOAA/PMEL)

Member, U.S. CLIVAR/CO₂ Repeat Hydrography Oversight Committee; Associate Editor, 2000, Journal of Physical Oceanography.

Michael McPhaden (NOAA/PMEL)

President of the Ocean Sciences Section of the American Geophysical Union (2 years); serves on the International CLIVAR Pacific; charter member of the new CLIVAR Global Synthesis and Observations Panel (GSOP) Panel and the CLIVAR GOOS Indian Ocean Panel (IOP); member of the JCOMM Observations Coordination Group; chairs the Tropical Moored Buoy Implementation Panel (TIP) which is an action group of the Data Buoy Cooperation Panel (DBCP); member of the OOPC/CLIVAR OceanSITES Working Group; member of the Bulletin of the American Meteorological Society editorial board.

Art Miller (SIO)

Member of U.S. CLIVAR Pacific Sector Implementation Panel; Member of U.S. GLOBEC Scientific Steering Committee.

Frank Millero (RSMAS/MAC)

Committees - Oversight Committee for the Repeat Hydrography Program (CLIVAR, CO₂/SCC) 2002-2004; Clair C. Patterson Award Committee, 2004; ACS Geochemistry Division Medal Committee, 2004; Sigma Xi, President-Elect, 2004-2006; AMLC Executive Board, 2004.

Mayra Pazos (NOAA/AOML)

WMO/IOC Data Buoy Cooperation Panel.

Ignatius Rigor (UW)

Coordinator of the International Arctic Buoy Programme (IABP); Member of National Aeronautics and Space Administration (NASA) Oceans and Ice Proposal Review Panel.

Dean Roemmich (SIO)

Serves on the U.S. CLIVAR Science Steering Committee, the international CLIVAR Global Synthesis and Observations Panel (GSOP), the JCOMM Observations Coordination Group, and the JCOMM Ship Observations Team's Ship of Opportunity Implementation Panel (SOOPIP).

Daniel Rudnick (SIO)

Co-chair of the CLIVAR Pacific Implementation Panel (PIP); Co-chair of the Autonomous and Lagrangian Platforms and Sensors (ALPS) workshop.

Christopher Sabine (NOAA/PMEL)

CARbon dioxide IN the Atlantic (CARINA); IGBP Integrated Global Carbon Observing (IGCO) theme team; US CLIVAR Southern Ocean panel; Member of International CLIVAR/CLIC Southern Ocean panel; Scientific Steering Committee member for IGBP/IHDP/WCRP Global Carbon Project; Working Group for the Implementation of the North American Carbon Program (NACP); Member of PICES Working Group 17: Biogeochemical Data Integration and Synthesis; Working Group for the Implementation of Ocean Carbon and Climate Change (OCCC) Program; Lead author for IPCC Special Report on carbon dioxide capture and storage.

Raymond Schmitt (WHOI)

Served on the Ocean Observing System Development Panel; served on CLIVAR International SSG; presently serves on the CLIVAR mixing process team; serves on the Editorial Board of Dynamics of Atmospheres and Oceans; recently served as a panel member for the NASA Oceans and Ice Review Panel, Aug. 30 – Sept 3, 2004.

Shawn Smith (FSU)

Ocean.US IOOS Expert Team on Archival and Access; WCRP Working Group on Surface Fluxes; Provide Pacific FSU wind fields each month for publication in the NOAA/CDC Climate Diagnostics Bulletin.

Taro Takahashi (LDEO)

Hosted a VOS/NOAA meeting held in September 2003 at the Lamont-Doherty Earth Observatory, NY; Participated in an advisory meeting on the NASA Suborbital Science Program, July 2004, held in Washington, D. C.

Rik Wanninkhof (NOAA/AOML)

NOAA carbon Steering Group; NOAA ocean CO₂ synthesis team; SOLAS implementation group 2 member; SOLAS implementation team 2, data liaison; SOLAS summer school organizing committee; Liege Colloquium Series on fluid dynamic: air-sea gas transfer- Science committee; Guest editor, special section JGR air-sea gas exchange; Opponent Ph.D. thesis of Abdirahman Oman, U. Bergen, Norway; Participant Cooperative Sensor Development Laboratory for Oceans of the University of South Florida; South Florida Meeting of CO₂ instrument development collaboration; Reviewer of the chemical oceanography program of the University of Concepcion, Chili; Partner in the European Union Carbon-Ocean Project.

Robert Weller (WHOI)

Provided preliminary design feasibility assessment of placing surface moorings in the Kuroshio Extension region to Meghan Cronin, PMEL; AGU, OS Section Executive Committee, Chair OS Section Awards Committee; Member, AGU-ALSO joint committee for Ocean Sciences meetings; Member, International CLIVAR SSG

Member, International CLIVAR Pacific Implementation Panel; Member CLIVAR VAMOS EPIC Science Team; Chair, CLIVAR VOCALS (VAMOS Ocean Cloud Atmosphere Land Study)

Science Team; Co-chair, U. S. CLIVAR Science Steering Committee; Member, UNESCO/IOC Ocean Observations Panel for Climate (OOPC); Member, UNESCO/WMO GOOS Capacity Building Panel; Member, NRC Environmental Satellite Data Utilization Committee, 2002-2004; Member, NRC Committee on Strategic Guidance to NSF Atmospheric Sciences Division, starting 2004

ORION (Ocean Research Interactive Observatories Network) Executive Steering Committee;

NOAA: Climate Observing System Council, Climate Council

Co-chair, International Time Series Science Team; CCSP Interim Ocean Carbon Implementation Group, 2002-2004; Chair of the NOAA Joint Institute Directors, July 2003-July 2004; Member, NOAA Senior Research Council, starting July 2003.

List of conferences/workshops presented at/attended

Frank Bahr (WHOI)

Climate Observation Program Workshop in Silver Spring, MD – April 2004; data conference.

Molly Baringer (NOAA/AOML)

CLIVAR-North Atlantic Thermohaline Circulation Variability Workshop, Kiel, Germany, September 2004; AGU Program committee meeting, September 2004, Washington, D.C.; Invited talk, What is the potential of different types of observation systems for detecting/monitoring MOC changes?; OCO Annual Review, April 2004, Silver Spring, Maryland; Aquarius/SAC-D-SMOS-HYDROS Joint Science Workshop on Salinity and Soil Moisture Remote Sensing, April 2004, Miami, FL.

Nicholas Bates (BBSR)

Meetings: Invited talk at IOS, Victoria, BC (December 2003); Invited talks at Univ. Rhode Island (March 2004).

Mark Bourassa (FSU)

US CLIVAR Southern Ocean working group workshop; CLIVAR04; COAPS site review; 13th Conference on Interactions of the Sea and Atmosphere; 20th Conference on Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction; 26th Conference on Hurricanes and Tropical Meteorology; EGU 1st General Assembly
2nd High Resolution Marine Meteorology Workshop; IGARSS04; 2004 Joint Assembly.

John Bullister (NOAA/PMEL)

First International CLIVAR Science Conference: Decadal changes along 20°W in the North Atlantic.

Francisco Chavez (MBARI)

Represented Central California at a meeting to Establish a National Federation of Ocean Observing Systems, Washington, DC March 31-April 1, 2003; Represented the U.S. at the Tenth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of “El Niño” and Meeting for Establishing the GOOS Regional Alliance for the Southeast Pacific (GRASP); Presented Seminar “From anchovies to sardines and back-Multidecadal change in the Pacific Ocean” at Food and Agriculture Organization in Rome on September 17, 2003; Invited speaker at Chapman conference on “The Role of Diatom Production and Si Flux and Burial in the Regulation of Global Cycles”, Paroikia, Paros, Greece, 22-26 September 2003; “What limits diatom production in the High Nitrate Low Chlorophyll regions of the Pacific Ocean?”; Invited panelist at "Marine Biodiversity In the Past: The Known, Unknown, and Unknowable", Scripps, November 15-17; Keynote presentation at conference series Classroom Exploration of the Oceans, December 15-19, "El Niño/La Niña"; Participant in ORION meeting and Moderator for Global Biogeochemical Cycles group in San Juan, Puerto Rico, January 4-8, 2004; Participant in Steering Committee meeting for OCEAN-SITES: A global network of timeseries stations, San Juan, Puerto Rico, January 5-9, 2004; Delivered plenary talk “A constant sea of change: The biological response to climate variability” at AGU Ocean Sciences. Portland, Oregon January 26, 2004; Steering Committee (with Hal Mooney, Margaret Palmer, William Schlesinger, Al Lucier) for Interagency Climate Change Science Plan Ecosystem Workshop, Washington, DC, February 22-24; Led the development of Science Committee for Central and Northern California Ocean Observing System (CeNCOOS); Participated in NSF Alan Waterman award committee meeting in Washington, DC, March 11, 2004; Delivered invited presentation “Biological consequences of interannual to multidecadal variability” at Scripps Spring Marine Biology Seminar Series, April

9, 2004; Participant in NASA's Ocean Color Research Team Meeting in Washington, D.C., 14-16 April 2004; Participant in NSF Geosciences Advisory committee meeting in Washington, DC, April 27-30, 2004; Participant as member of Board of Governors in Pacific Coastal Observing System (PaCOS) meeting, Scripps, May 17-18, 2004; Participant in North Pacific Carbon workshop in Seattle, WA on June 4-6. Delivered invited presentation on "Biogeochemical consequences on interannual to multidecadal climate variability"; Presented talk on "Autonomous measurements of carbon dioxide" at MBARI Day of Science and Technology; Traveled to Lima, Peru on July 2-8 to deliver autonomous systems for measurement of pCO₂ to Peruvian fisheries and oceanography institute; Participated in workshop on hyperspectral remote sensing of US coastal waters in NASA/JPL on September 15-16; Participant in International Council for Exploration of the Seas (ICES) meeting in Vigo, Spain and delivered invited talk "Evidence for Regime Shifts in the Pacific Ocean" on September 23; presented at Instituto de Investigaciones Marinas "De Peru a California y de regreso: mi fascinación con las áreas de afloramiento" on September 22.

Steven K. Cook

High Resolution Marine Meteorology Workshop; NWS/Port Meteorological Officer Conference; OCO Annual review.

Bruce Cornuelle, Detlef Stammer, Art Miller (SIO)

Presentation at the ECCO meeting, MIT, Boston, August 2004; Poster at CLIVAR meeting, Baltimore, June 2004; Workshop on Climate Variability in the 20th Century ICTP, Trieste, Italy April 2004; Technical Workshop on Regional Modeling for the Southeastern Pacific CIIFEN, Guayaquil, Ecuador, June 2004; Presentation at 36th International Liège Colloquium on Ocean Dynamics, Liège, May 2004; Presentation at 1st EGU General Assembly, Nice, April 2004.

Meghan Cronin (NOAA/PMEL)

"KESS and Beyond" science meeting at JAMSTEC, Yokohama, Japan (co-organizer), 5 June 2004; AMS annual meeting, Seattle WA, 14 Jan 2004; Ocean Sciences meeting, Portland OR, 28-30 January 2004; U.S. CLIVAR PanAmerican Panel meeting, Baltimore, MD, 20-21 June 2004; CLIVAR2004 Conference, Baltimore, MD, 21-25 June 2004; AMS 13th conference on interactions of the Sea and Atmosphere, 9-10 Aug 2004.

Yeun-Ho Chong Daneshzadeh

GTSP meeting, Southampton, England.

Craig Engler (NOAA/AOML)

ONR/MTS Buoy Workshop.

Chris Fairall (NOAA/ETL)

25th Session of the Joint Scientific Committee for the WCP, World Climate Research Program, Moscow, Russia, 1-6 March 2004; Presentation: The WCRP Working Group on Surface Fluxes; Seventh Annual Meeting of the WCRP/CLIVAR VAMOS Panel, NOAA-OGP, Guayaquil, Ecuador, 22-25, March, 2004; Office of Climate Observation Annual System Review, NOAA, Silver Spring MD, 13-15 April 2004; Poster presented: Cloud forcing of the surface energy budget of the ITCZ/Cold Tongue complex in the tropical Eastern Pacific; Second Workshop on High-Resolution Marine Meteorology, NOAA, Silver Spring, MD, 15-16 April, 2004; Paper presented: High-Resolution Climate Data from Research and Volunteer Observing Ships: A Strategic Intercalibration and Quality Assurance Program; Focus 2 Working Group for the International SOLAS Implementation Plan, Surface Ocean-Lower Atmosphere Study, IGBP, Montreal, Canada, 17-19 May, 2004; First International CLIVAR Scientific Conference, WCRP,

21-25 June, 2004; Posters given: 1) Cloud forcing of the surface energy budget of the ITCZ/Cold Tongue complex in the tropical Eastern Pacific, 2) Investigation of air-sea interaction and cloud processes in the EPIC stratocumulus region.

Richard Feely (NOAA/PMEL)

NOAA Carbon Steering Group Meeting, November 2003; AGU San Francisco and Town Hall Meeting of OAR Review Team, December 2003; IOCCP/PICES/NIES Workshop on Ocean Surface pCO₂, Data Integration and Database Development in Tsukuba, Japan, January 14-17, 2004; Center of Ocean Technology Meeting, St. Petersburg, FL, March 11-12, 2004; Office of Climate Observation Annual Review, Silver Spring, MD, April 13-15, 2004; Oceans in a High CO₂ World Meeting, Paris France, May 10-12, 2004; Ocean Dialogues, University of Washington, March 19, 2004; NOAA Carbon Science Team Meeting, Boulder, CO, May 25, 2005; North Pacific Carbon Cycle Workshop, Seattle, WA, June 2-4, 2004; AAAS/NOAA Press Conference, Washington DC, July 15, 2004; Mediterranean Conference on Chemistry of Aquatic Systems in Reggio Calabria, Italy, September 4-8, 2004. Testimony on impacts of Anthropogenic CO₂ in the Oceans before the Senate Commerce Committee, September 21, 2004.

Silvia Garzoli (NOAA/AOML)

OCO Annual review; CLIVAR-North Atlantic Thermohaline Circulation Variability Workshop, Kiel, Germany, September 2004.

Gustavo Goni (NOAA/AOML)

EGU 2005 Meeting, Nice, France, April 2004; Tropical Atlantic Workshop, Utrecht, The Netherlands, June 2004; IEEE's IGARSS Meeting, Anchorage, September 2004.

Ed Harrison (NOAA/PMEL)

JCOMM GLOSS-8, October 2003; US GOOS, SC November 2003; US GOOS work group December 2003; POGO-5 November 2003; NRC Climate Data Records, December 2003; GCOS 2AR IP, January 2004; GOOS COOP-6, January 2004; WCRP JSC25 Moscow, March 2004; GCOS SC, March 2004; JCOMM MAN-3, March 2004; OCO COSC, April 2004; AOPC, April 2004; GOOS SC, April 2004; JCOMM OceanOPS04, May 2004; US GOOS SC, May 2004; OOPC SOC, June 2004; CLIVAR SSG, June 2004; GCOS 2AR IP-Chairs, July 2004; Intl GODAE ST-9, July 2004; GCOS 2AR IP, August 2004; US IOOS Implementation, September 2004; US GODAE ST, September 2004; SCOR Coordination, September 2004; SCOR General Meeting, September 2004.

Dave Hosom (WHOI)

Climate Observation Program Workshop in Silver Spring, MD – April 2004; data conference.

Elizabeth Johns (NOAA/AOML)

SEACOOS meeting, Miami, FL, May 2004

Gregory Johnson (NOAA/PMEL)

Argo Data Management Meeting, November 2003, Monterey, California; First Argo Science Workshop, November 2003, Tokyo, Japan; 2004 Ocean Science Meeting, January 2004, Portland, Oregon; NOPP 2003 Excellence in Partnering Award for the Argo Program, February 2004, Washington DC; OCO Annual Review, April 2004, Silver Spring, Maryland; 2004 Eastern Pacific Ocean Conference, September 2004, Victoria, Canada.

Rick Lumpkin (NOAA/AOML)

ONR/MTS Buoy Workshop, Aquarius/SAC-D-SMOS-HYDROS Joint Science Workshop; OCO Annual Workshop; EGU First General Assembly, Nice, France, 25-30 April 2004 (presentation); DBCP meeting, October 16-19, Chennai, India: “Global Drifter Program”.

Nikolai Maximenko (UH)

GODAE International Workshop, St. Petersburg, FL, November 2004: “The dynamics of ocean surface circulation studied using altimeter, Lagrangian drifter and wind data”.

Michael McPhaden (NOAA/PMEL)

Participated in the Fall 2003 AGU meeting (San Francisco, December 2003) and Spring 2004 AGU meeting (Montreal, Canada, May 2004), the inaugural IOP meeting (Pune, India, February 2004); the NOAA Climate Observation Workshop (April 2004, Washington, DC); the High-Resolution Marine Meteorology meeting (April 2004, Washington, DC); and the CLIVAR SSG-13 meeting (Baltimore, MD, June 2004); Awarded Presidential Rank Award for Meritorious Federal Service; participated in the Change of Command Ceremony for the NOAA Ship Ka'imimoana (Honolulu, August 2004).

Christopher Meinen (NOAA/AOML)

SEACOOS meeting, Miami, FL, May 2004; 2004 Ocean Sciences Meeting, Portland, OR, January 2004.

Mark Merrifield and UHSLC personnel

IUGG, Sapporo, Japan, July 2003, paper on decadal sea level in the Pacific; GLOSS Group of Experts meeting, Paris, October 2003, presentation on importance of real-time data reporting; Annual American Meteorological Society Meeting, January 2004, presented two papers, one on data portals and another showing some sea level trends in the Pacific; 1st CLIVAR Planning Meeting on Ocean Observations, March 2004, presentations on in situ sea level observations and data management and distribution, and report on the UHSLC CLIVAR in situ sea level DAC; Federal Hazard Mitigation Partners in the Pacific Islands, Honolulu, March, co-chaired a working group on ocean observatories; Climate Observation Program Workshop, Silver Spring, April 2004, poster presented on activities of the UHSLC; India-US Climate Change Science Workshop, Delhi, July 2004, (UHSLC personnel); Served on the GOES working group, Seattle, August 2004 (UHSLC personnel); Pacific Data Management Meeting, September 2004, (UHSLC personnel), presented several papers on the state of sea level in the Pacific Ocean region; The UHSLC director was selected for a term as the GLOSS chair, and center personnel also serve on the GLOSS Scientific Steering Committee; UHSLC personnel serve on the National Oceanographic Partnership Program Ocean.US Applications and Products Expert Team (see Hankin et al., 2004 for a recent report on their activities).

Laury Miller (NOAA/NESDIS)

Oral/Poster Presentations (some with co-authors)

“Improved ERS and ENVISAT Precise Orbit Determination”, ENVISAT Symposium, Salzburg, Sept., 2004; Sea Ice Elevation from Laser Altimetry using ICESat/GLAS, Arctic Climate System Study (ACSYS) Final Science Conference, St. Petersburg, Russia, November, 2003; “The Correspondence of Altimetric Gravity Texture to Abyssal Hill Morphology”, AGU Fall Mtg, 2003; “Improving Ocean Analyses and ENSO Forecasts at NOAA Using the Global Ocean Data Assimilation System and Altimetric Sea Level”, ENVISAT Symposium, Salzburg, Sept., 2004; “Rain and Ice Flagging of ENVISAT Altimeter and MWR Data”, ENVISAT Symposium, Salzburg, Sept., 2004; “Satellite Monitoring of Tropical Pacific Ocean Temperatures, Currents and Color During the 1998 El Nino”, Third GOES-R Users Conference, Broomfield, Colorado, May 2004; High Accuracy Gravimetric Geoid for Arctic Research (HAGGAR) From GRACE,

Airborne, and Surface Data, GRACE Science Team Mtg, Univ. of Texas Center for Space Research, October, 2003; “Arctic Ocean Geoids From GRACE and Surface Gravity Data: Comparisons With Altimetric Sea Surface Topography”, Spring AGU, Montreal, Canada; “Capturing Large-Scale Change in the Arctic Ocean and Cryosphere”, Union Session of the International Polar Year 2007-2008, Spring AGU, Montreal, Canada; “Altimetric gravity and sea surface topography of the Arctic Ocean: Comparisons with gravimetry”, IAG GGMS, Porto, Portugal, Sept., 2004; Mass and Volume Contributions to 20th Century Global Sea Level Rise, Jason Science Working Team Mtg, Arles, France, November 2003; “Mass and Steric Contributions to 20th Century Global Sea Level Rise”, Celebration of UK Sea Level Science, Royal Society, London, Feb., 2004; “Global Sea Level Rise: The Past Decade Versus the Past Century”, Joint meeting of the NOAA Science Advisory Board Climate & Global Change Working Group and Climate Monitoring Working Group, Duck Key, Florida, April 2004; “Mass and Volume Contributions to 20th Century Global Sea Level Rise”, ESSIC Seminar Series, University of Maryland, April 2004; “Sea Level Observing System Issues”, Office of Global Programs Annual Review, Silver Spring, Maryland, April 2004; Mass and Volume Contributions to 20th Century Global Sea Level Rise, NOAA Library Brown Bag Seminar, May 2004; “Global Sea Level Rise: The Past Decade vs. the Past 100 Years, COSPAR”, Paris, July 2004; “Global Sea Level Rise: A Decade of Multi-Satellite Altimeter Observations versus 100 Years of In-situ Observations”, AIAA Space 2004, San Diego, Sept. 2004; “Bathymetry from Space: Geophysics, Oceanography, and Climatology”, ENVISAT Symposium, Salzburg, Sept. 2004; Cross-calibration and long-term monitoring of the microwave radiometers of ERS, TOPEX, GFO, Jason and Envisat, Jason Science Working Team Mtg, Arles, France, November 2003; “Multi-Satellite Altimetric Sea Level Change: 1992-2003 What Do We Know and What Not?”, EGU04, Nice, France, April 2004; “Cross-calibration and Long-term Monitoring of the Radiometers of ERS-1, TOPEX/Poseidon, ERS-2, GFO, Jason-1 and Envisat”, EGU04, Nice, France, April 2004; “Non-Parametric Sea-state Bias Models and Their Relevance to Sea Level Change Studies”, ENVISAT Symposium, Salzburg, Sept. 2004; Correlating the textures of altimetric gravity and multibeam bathymetry, AGU Fall Mtg, 2003; “Bathymetry for Hydrodynamic Models: Not All Bathymetry Grids Are Created Equal, and Why It Matters to Modelers”, NOAA Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey, May 2004; “Bathymetry From Space: Geophysical Issues”, Department of Geosciences, Princeton, New Jersey, May 2004.

Frank Millero (RSMAS/MAC)

Meetings – Lecture at University of South Florida, St. Petersburg, FL, April 2004; SAML Meeting, Galveston, TX, May 12-14, 2004; M. González-Davila, J.M. Santana-Casiano and F.J. Millero, Oxidation of iron (II) nanomolar with H₂O₂ in seawater, 13th Annual V.M. Goldschmidt Conference, Copenhagen, Denmark, June 5-11, 2004, poster session; Gordon Research Conference, Bates College, Lewiston, Maine, June 20-25, 2004; AMLC Executive Board meeting/workshops, GRENADA, July 20-25, 2004; Invited lecturer, F.J. Millero, “The thermodynamics of carbonic acid in natural waters,” Mediterranean Conference on Chemistry of Aquatic Systems in Honor of Frank J. Millero, Reggio Calabria, Italy, 4-8 September 2004; Elsevier Editor’s Conference, Santa Fe, NM- October 29-31, 2004; Greensboro, NC, SLOAN Conference, November 3-5, 2004.

Robert Molinari (NOAA/AOML)

OCO Annual review.

Calvin Mordy (JISAO/UW)

EPOC, September 2003, Sydney, BC; NPCREP Workshop, September 2003, Seattle, WA; NEP GLOBEC, January 2004, Portland, OR; AGU Ocean Sciences, January 2004, Portland, OR;

Marine Science in Alaska 2004 Symposium, January 2004, Anchorage, AK; ASLO Conference, February 2004, Honolulu, HI; PICES, October 2004, Republic of Korea.

Peter Niiler (SIO)

Ocean Observations for Climate “Workshop”, April 2004, Silver Spring, MD; Invited Faculty Lecture, UCLA Department of Atmospheric Sciences, October 27, 2004: “The observed surface circulation of the globe: New perspectives from drifters and satellite sensors”.

James O’Brien (FSU)

COAPS site review.

Observing System Monitoring Center Team

American Meteorological Society meeting, January 2004, Seattle; OCO Annual System Review, April, Silver Spring, MD.

Al Plueddemann (WHOI)

ChalkEx PI Meeting, UNH, 16 October 2003; ONR Northeast Region Site Review, 20 November 2003; Roundtable Discussion on Ocean Exploration, U-Mass Dartmouth, 13 January 2004; NE-COSEE Telling Your Story Workshop, NE-COSEE, WHOI, 22 January 2004; AGU Ocean Sciences Meeting, 26-30 January 2004; NOAA Office of Climate Observations Workshop, 12-14 April 2004; SOLAS IMP-2 Workshop, 17-19 May 2004; ChalkEx PI Meeting, UNH, 27 May 2004; First International CLIVAR Science Conference, 21-24 June 2004; Ice Tethered Profiler Workshop, 28-30 June 2004; AMS 16th Conf. on Boundary Layers and Turbulence, 9-13 August, 2004.

Richard Reynolds (NCDC)

Presentations:

Sea Surface Temperature (SST) Analyses for Climate and Their Errors, Presented at the Second Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Workshop on Advances in Marine Climatology, Brussels, Belgium, November 17-22, 2003; GCOS SST/Sea-Ice Working Group progress, Presented at the Ninth Ocean Observations Panel for Climate Meeting, Southampton Oceanographic Centre, Southampton, United Kingdom, 7-11 June 2004; In situ SST network with a focus on buoy requirements, Presented at the Climate Observation Annual System Review, Silver Spring, MD, April 13-15, 2004; Sea Surface Temperature Analyses for Climate, Presented at the Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), Hobart Australia, July 19, 2004.

Jackie Richter-Menge (CRREL)

Presentations (some with co-authors):

An autonomous network measuring changes in the thickness of the Arctic sea ice cover, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; Recent Progress Towards Establishing an Arctic Ocean Observing System - A NOAA Contribution to the Study of Environmental Arctic Change (SEARCH), Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; National Oceanic and Atmospheric Administration (NOAA) Arctic Climate Change Studies: A Contribution to IPY, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; Recent Progress Towards Establishing an Arctic Ocean Observing System, Proc. Arctic Climate Impacts Assessment (ACIA) International Symposium on Climate Change in the Arctic, Reykjavik, Nov. 2004; The NOAA Arctic Climate Change Studies: A U.S. Contribution to Arctic Council Responses to the ACIA, Proc. Arctic Climate Impacts Assessment (ACIA) International Symposium on Climate Change in the Arctic, Reykjavik, Nov. 2004.

Ignatius Rigor (UW)**Presentations (some with co-authors):**

Explaining the Recent Decreases in Sea Ice on the Arctic Ocean, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; Recent Progress Towards Establishing an Arctic Ocean Observing System - A NOAA Contribution to the Study of Environmental Arctic Change (SEARCH), Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; National Oceanic and Atmospheric Administration (NOAA) Arctic Climate Change Studies: A Contribution to IPY, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; The International Arctic Buoy Programme (IABP) – An International Polar Year Every Year, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; An autonomous network measuring changes in the thickness of the Arctic sea ice cover, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; Observed Changes at the Surface of the Arctic Ocean, Eos Trans. AGU, Fall Meet. Suppl., Dec. 2004; Recent Progress Towards Establishing an Arctic Ocean Observing System, Proc. Arctic Climate Impacts Assessment (ACIA) International Symposium on Climate Change in the Arctic, Reykjavik, Nov. 2004; Variations in Arctic Sea Ice, Proc. Arctic Climate Impacts Assessment (ACIA) International Symposium on Climate Change in the Arctic, Reykjavik, Nov. 2004; The NOAA Arctic Climate Change Studies: A U.S. Contribution to Arctic Council Responses to the ACIA, Proc. Arctic Climate Impacts Assessment (ACIA) International Symposium on Climate Change in the Arctic, Reykjavik, Nov. 2004; Variations in Arctic Sea Ice, Proc. ARCUS Workshop, Washington, D.C., May 2004; Recent Progress Towards Establishing an Arctic Ocean Observing System, Proc. NOAA Ocean Climate Observing System Review, Silver Spring, MD, Apr. 2004; Climate Observing System for Arctic Ocean, Proc. Marine Science in Alaska: 2004 Symposium, Anchorage, Jan. 2004; Variations in the Age of Sea Ice and Summer Sea Ice Extent, Lamont Mini-conference, Central Arctic: Battleground of Natural and Man-Made Climate Forcing, Lamont Doherty Earth Observatory of Columbia University, New York, Jan. 2004; Predicting the Extent of Sea Ice in the Arctic, Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract OS11B-06, Dec. 2003; The International Arctic Buoy Programme (IABP), Proc. Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract C41C-0987, Dec. 2003; Assessing, understanding, and conveying the state of the Arctic sea ice cover, Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract C41C-0990, Dec. 2003; Recent Progress Towards Establishing an Arctic Ocean Observing System, Proc. NOAA Ocean Climate Observing System Review, Silver Spring, MD, Apr. 2004; Assessing, understanding, and conveying the state of the Arctic sea ice cover, Eos Trans. AGU, 84 (46), Fall Meet. Suppl., Abstract C41C-0990, Dec. 2003; The National Oceanic and Atmospheric Administration (NOAA) SEARCH Initiative, SEARCH Open Science Meeting, October 2003.

Daniel Rudnick (SIO)

Fall American Geophysical Union 2004 meeting.

Christopher Sabine (NOAA/PMEL)

IOCCP/PICES/NIES Workshop on Ocean Surface pCO₂, Data Integration and Database Development in Tsukuba, Japan, January 14-17, 2004 (co-organizer and working group 1 rapporteur); MOSEAN meeting, Honolulu, HI, February 21, 2004 (invited talk on PMEL moored pCO₂ system); Center of Ocean Technology meeting, St. Petersburg, FL, March 11-12, 2004 (invited talk on PMEL moored pCO₂ system); Office of Climate Observation Annual Review, Silver Spring, MD, April 13-15, 2004 (2 posters – Moored pCO₂ program; Carbon/CLIVAR repeat hydrography program); Oceans in a High CO₂ World Meeting, Paris France, May 10-12, 2004; NOAA Carbon Science Team Meeting, Boulder, CO, May 25, 2005; North Pacific Carbon Cycle Workshop, Seattle, WA, June 2-4, 2004 (meeting organizer); MOSEAN Mooring, Honolulu, HI, July 26-28, 2004 (Stacy Maenner and I made a presentation of Hawaii group about pCO₂ moorings and mounted the pCO₂ system in the MOSEAN mooring); Mediterranean Conference on Chemistry of Aquatic Systems in Reggio Calabria, Italy, September 4-8, 2004.

William Scuba (SIO)

DBCP meeting, October 16-19, Chennai, India: “Hurricane Drifter Deployment Results”.

Raymond Schmitt (WHOI)

Salinity and Soil Moisture Remote Sensing Workshop, April 20-22, 2004, Miami, FL. Board of Atmospheric Sciences, National Academy of Sciences Summer Workshop, July 12-13, 2004, Woods Hole, MA.

Shawn Smith (FSU)

84th AMS Annual Meeting; 150th Anniversary of the Brussels Maritime Conference of 1853; CLIMAR-II, Second JCOMM Workshop on Advances in Marine Climatology
Climate Prediction Applications Science Workshop; 1st CLIVAR Data Planning Meeting on Ocean Observations; CLIVAR04; COAPS site review; 2nd High Resolution Marine Meteorology Workshop; Office of Climate Observation Annual System Review; 1st Workshop on the Quality Assurance of Real-Time Ocean Data.

Taro Takahashi (LDEO)

“Distribution and systematics of the pCO₂ in surface waters of the global ocean”, a key note address delivered at the International Workshop on the Surface Water pCO₂” held in January, 2004, Tsukuba, Japan; “Decadal changes in the surface water pCO₂ in the tropical and North Pacific Ocean”, an invited presentation at the “Workshop on the temporal change in the carbon chemistry of the North Pacific Ocean”, held in June 2004, Seattle, WA.

Rik Wanninkhof (NOAA/AOML)

NOAA Carbon Steering Group Meeting, November 2003; AGU San Francisco and town hall meeting of OAR review team, December 2003; IOCCP pCO₂ methods workshop, Tsukuba, Japan, January 2004; COSP meeting, April 2004; NOAA Carbon Steering Group Meeting, May 2004; SOLAS Implementation Group 2 meeting, Montreal, May 2004; Oceans in a high CO₂ world meeting, Paris, May 2004; Caribbean: Media cruise Explorer of the Seas, Caribbean, June 2004; AAAS press conference, July 2004; SOLAS Implementation Group 2 writing team meeting, September 2004.

Robert Weller (WHOI)

Ocean Observations Panel for Climate (OOPC), Ottawa, Sept 2003; NRC Committee, Environmental Satellite Data Utilization, Sept 2003; PACS/EPIC PI workshop, NCAR, Sept 2003; DEOS Executive Committee, San Francisco, Oct 2003; NRC CCSP Committee, Irvine, Oct 2003; NOAA CIMMS site review, Norman, OK, Oct 2003; NRC Committee on Environmental Satellite Data Utilization, Irvine, Dec 2003; Fall AGU, OS Exec. Committee, San Francisco, Dec 2003; US CLIVAR SSC, Lamont Doherty, Dec 2003; ORION workshop, Puerto Rico, Jan 2004; International Time Series Science Team Meeting, Puerto Rico, Jan 2004; Interagency Working Group on Earth Observations, Dulles, VA, Jan 2004; Ocean Sciences Meeting, Portland OR, Jan 2004; NRC Committee, Environmental Satellite Data Utilization, Wash DC, Feb 2004; NOAA Senior Research Council, Silver Spring, MD, Feb 2004; NOAA Climate Council meeting, Airlie House, VA, March 2004; VAMOS (Variability of the American Monsoon Systems) Panel mtg, Guayaquil, Ecuador, March 2004; Climate Observation Program Workshop in Silver Spring, MD, April 2004; NOAA Joint Institutes Director and Administrators Meeting, Silver Spring, April 2004; ORION Executive Steering Committee, Wash DC, April 2004; CICOR Executive Board and Fellows meetings, WHOI, May 2004; ONR Non-Linear Internal Waves and Parameterization DRI meetings, Dulles, VA, May 2004; Meet with Adm. Jay Cohen, CNR, Wash DC, May 2004; Meet with Chet Koblinsky, NOAA OAR Climate team lead, May 2004; OOPC meeting,

Southampton Oceanography Centre, UK June 2004; Interagency Working Group on Earth Observations, Herndon, VA, June 2004; CLIVAR Conference, Baltimore, June 2004; International CLIVAR SSG, Baltimore, June 2004; ORION Executive Steering Committee, July 2004; Testimony at House hearing, Wash DC, July 2004; NRC Committee on Strategic Guidance for NSF ATM, Wash DC, August 2004.

Jia-Zhong Zhang (NOAA/AOML)

Mediterranean Conference of Chemistry of Aquatic Systems, September 2004, Reggio Calabria, Italy.

Outreach (e.g., education initiatives, press/media interviews, public lectures)

AOML

Data has been used for educational purposes at the University of Miami and at public schools across the nation.

Steven Cook (NOAA/AOML)

VOS Recruitment Presentations to: Bermuda Container Lines, Maersk Sea-Land Inc. SCMI.

Gustavo Goni (NOAA/AOML)

Mentor of high school student during Summer 2004; Article on Tropical Cyclone Heat Potential, The Miami Herald, January 25, 2004.

Elizabeth Johns (NOAA/AOML)

SEACOOS meeting, Miami, FL, May 2004.

Rick Lumpkin (NOAA/AOML)

Mentored an undergraduate student of City College of New York (CCNY) in a data analysis summer project, supported by NOAA funding separate from this project; made presentations for the general public in Miami, and for computer science undergraduates at CCNY.

Christopher Meinen (NOAA/AOML)

SEACOOS meeting, Miami, FL, May 2004.

Frank Millero (RSMAS/MAC)

Outreach – Sloan Conference Mentor, 2004.

Ignatius Rigor (UW)

Assisted with the development of graphics describing Arctic change in the National Geographic Article, Arctic Ice (2004); Gave a lecture on Arctic climate change and sea ice at the U.W. Program on Climate Change (PCC) Summer Institute, Leavenworth, WA, September 2004.

Raymond Schmitt (WHOI)

Interviewed this year on the Weather Channel, for the History Channel, and for numerous newspapers. Presented invited lecture on the oceans and climate at the Beckman Scholars Symposium, July 31 at National Academy of Sciences, Irvine, CA.

Robert Weller (WHOI)

We will have the NOAA Teacher-at-Sea program involved in our cruise in December 2004; Briefing on climate observation of Ocean Science Journalism Fellows, WHOI, September 2004.

APPENDIX D

Request for Annual Progress Report and Report Format

18 August 2004

Dear Climate Observationalists:

Thank you to all who participated in the Climate Observation Program's Annual System Review held from 13-15 April in Silver Spring, MD. The meeting provided continued direction for the development of the sustained global climate observing system. The illustrated poster sessions highlighted observing system progress and needs in addition to the science contributing to modeling and user efforts, thus complementing presentations by user groups and partners. In response to requests to focus more strongly on the science and accomplishments of the observing system we intend to hold a technical science workshop in conjunction with next year's Program Review. The 2005 Climate Observation Program Review and the Technical Science Workshop are tentatively scheduled for 26-28 April. Please place these dates on your 2005 calendar.

Following is a request for annual progress reports for FY 2004, work plans for FY 2005, and additional tasks. Note that this year proposals for additional tasks for ocean analysis will be accepted from the operational centers and other institutions as well as from existing projects. Please see the "Add Tasks" document for more detail. Your FY 2003 reports were outstanding and formed the bulk of Chapter 3 of the first *Annual Report on the State of the Ocean and the Ocean Observing System for Climate* (hereafter referred to as the *Annual State of the Ocean Report*). Your reports were also used to update the Program Plan for *Building a Sustained Ocean Observing System for Climate*. Both documents can be found on the Office of Climate Observation (OCO) web site at <http://www.oco.noaa.gov/> under "Reports and Products" and "Program Plan", respectively. We appreciate your contributions to the *Annual State of the Ocean Report*.

Following last year's guidelines, your annual progress report should include: 1) a project summary, 2) FY 04 progress, 3) a FY 05 work plan, 4) a corresponding FY 05 budget, and 5) "Add Tasks". Attachment 1 is a slightly revised outline of the report format, including guidelines. The guidelines are intended to provide a somewhat standard look and feel across all the projects and to allow the Project Office to extract summary information and system-wide statistics to streamline preparation of the *Annual State of the Ocean Report*, provide information for other system reports, and to respond to questions from NOAA management.

Please remember that if your lab/center is implementing more than one project, we would appreciate receiving a single annual report for each network. The Project Office's *Annual State of the Ocean Report* will summarize progress by "network" (as per the JCOMM panels and per our Program Plan). If your lab/center works across several networks, please report these separately. For example, AOML's GOOS Center would file separate annual reports for the SOOP work and for the Global Drifter Program work. It may be difficult to break out personnel costs, etc., between projects if the same people work on more than one, but please provide your best estimate of the separation.

For FY 05, it is the intent of the Climate Observation Program to sustain existing projects at the FY 04 level of funding (depending on the appropriation/allocation process, of course). The budget sheet and cover sheet of your annual report should reflect the "base" budget level (i.e., FY 04 level) for FY 05 work.

Please remember that project managers should evolve their work within their "base" budget to achieve maximum effectiveness and efficiency as scientific understanding and technology advance. Any significant changes, however, must be accomplished in accordance with the Ten

Climate Monitoring Principles and in cooperation with the international implementation panels, in particular the JCOMM panels and the IOCCP. The Ten Principles are listed at the end of the Report Format/Guidelines document.

In addition to your base project Tasks, there is an opportunity to include “Add Tasks” with your report. The Add Tasks should outline incremental expansions and improvements that you would like to accomplish if additional funding becomes available. The Program’s specific needs for FY 05 Add Tasks are detailed in the attached Add Tasks document. Please include a cost estimate for each Add Task. When/if new funding becomes available, the Project Office will review and evaluate the Add Task requests against Program priorities. For selected Add Tasks we will ask for a detailed budget sheet to document a supplement to your annual work plan. In most cases, the selected Add Tasks will then become part of the project’s base funding for following years.

Budget planning values for FY 05 are included in the Add Tasks document. This plan was used to document NOAA’s request for a FY 05 budget increase. You should use this as guidance in creating your Add Tasks. Of course, the Federal appropriation and NOAA allocations seldom equate to the budget planning. So, if possible, develop several modestly priced Add Tasks that could build the system incrementally according to actual funding availability. Please list your Add Tasks in your recommended priority order.

The FY 05 budget planning represented in the Add Tasks document was put in place two years ago and is, therefore, subject to modification. We continue to be serious about building an observing system that is responsive to our customers’ requirements and are prepared to adjust course according to customer feedback. Therefore, we will constantly review user input and may modify planning and priorities as we move forward; the ratios of new funding applied to the networks may vary from the attached FY 05 plan. You should use it as guidance but should not be constrained by it.

Please submit your annual progress report and work plan by 15 October 2004 so that we can move money to you as soon as it becomes available in the fiscal year. It is also imperative that your reports be received on time because they will be used in developing a concise summary of the state of the ocean to be submitted for consideration in the *State of the Climate in 2004* Report completed by the NCDC for publication in a late spring 2005 issue of the *Bulletin of the American Meteorological Society* (BAMS). The deadline for the ocean contribution to this report is early 2005.

METHOD OF SUBMISSION

Your report should be submitted electronically by 15 October to climate.observation@noaa.gov.

Follow with hard copy to:
NOAA Office of Climate Observation
1100 Wayne Avenue, Suite 1202
Silver Spring, MD 20910
1-301-427-2089

Thank you for your continued dedication to building the sustained ocean observing system for climate.

Sincerely,
Diane Stanitski

PROGRESS REPORT AND WORK PLAN FORMAT / GUIDELINES

Overview

1. Cover Page
2. Project Summary
3. FY 2004 Progress
4. FY 2005 Plans
5. FY 2005 Budget
6. Add Tasks
7. Appendices

Please include the following information, where applicable, in your annual progress reports. Be as concise and comprehensive as possible and include the full name of all projects and acronyms used. Graphics are encouraged as a means to present your status and findings. Please provide a map(s) indicating locations instrumented or analyzed.

COVER PAGE

- Project title
- Report date – 15 October 2004
- Project Manager(s) – name, title, affiliation, address, phone, email for each
- Primary contact person for finance – name, phone, email
- Signature for person(s) responsible/accountable, e.g. Lab Director

PROJECT SUMMARY

- General overview of the project, including brief scientific rationale
- Statement about how your project addresses NOAA's Program Plan for *Building a Sustained Ocean Observing System for Climate*
- Statement about how your project is managed in cooperation with the international implementation panels, in particular the JCOMM panels
- Responsible institutions for all aspects of project
- Project web site URL and pertinent web sites for your project and associated projects
- Interagency and international partnerships
- Statement that your project is managed in accordance with the Ten Climate Monitoring Principles (see end of this document)

FY 2004 PROGRESS

- Instrument/platform acquisitions for fiscal year and where equipment was deployed (provide map)
- Number of deployments – compare to the previous year
- Percentage data return for fiscal year and 'lifetime' statistics – compare to the previous year
- Measurements taken, where data are stored, data distribution, availability and access to data
- How data are currently being used and shared
- Where the data are archived
- Problems encountered
- Logical considerations (e.g., ship time utilized)
- Research highlights
- Community service (e.g., appointments to science and implementation panels)
- List of conferences/workshops presented at/attended
- Outreach (e.g., press/media interviews, public lectures)

- A bibliography of all refereed publications, technical reports, and meeting proceedings related to your project published and in press during the last fiscal year, including references to papers using data accessed through your project. Please use the *Bulletin of the American Meteorological Society* as the style guide for your bibliographic entries. In addition, include the pdf or url where each complete article or report can be found online. Highlight one or two of your most important FY 04 refereed publications, and include the abstract for these papers in your report and a copy of each publication in its entirety in your Appendix. These particular publications will be highlighted in Chapter 4 of the Annual Report. In addition, send one paper copy of ALL publications, reports, etc. related to your project directly to the OCO with the hard copy of your report.

FY 2005 PLANS

Please include the following information, if applicable:

- Anticipated requirements to maintain the network at status quo
- New data collection methods
- Expected scientific results

FY 2005 BUDGET

- Show Program funding requirements
- Show non-Program support for the observing system (e.g., PI salary)
- Identify how much of your total budget goes toward: a) operations, b) data management, and c) R & D
- Identify how many FTEs the Program funding supports – a) Federal FTEs, and b) non-Federal FTEs.
- Identify how many FTEs dedicated to the project are not funded by the Program

ADD TASKS – see attachment for guidelines (1, 2, 3, 4)

- Rationale
- Proposed work
- Procurements needed
- Additional personnel needed
- **Cost estimate**

APPENDICES

- Copy of representative publication(s)
- List of Acronyms used in your report

THE 10 CLIMATE MONITORING PRINCIPLES

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms, and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional, and global observing priorities.
6. Operation of historically uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators, and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully planned manner should be promoted.
10. Data management systems that facilitate access, use, and interpretation of data and products should be included as essential elements of climate monitoring systems.

APPENDIX E

Contributors and Reviewers: Annual Report

Contributors and Reviewers

Chapter 1: The Role of the Ocean in Climate – *Kevin Trenberth, NCAR, Boulder, Colorado*

Chapter 2: The State of the Ocean

2.1 Global sea level rise – *Laury Miller and Bruce Douglas, NOAA/NESDIS, Silver Spring, Maryland*

2.2 Sea surface temperatures in 2004 – *Richard Reynolds, National Climatic Data Center, Asheville, North Carolina*

2.3 Ocean heat and fresh water content and transports – *Lynne Talley, Scripps Institution of Oceanography, California*

2.4 Evolution of the 2004 El Niño – *Michael McPhadean, Pacific Marine Environmental Laboratory, Seattle, Washington*

2.5 The global ocean carbon cycle: Inventories, sources and sinks – *Richard Feely, Pacific Marine Environmental Laboratory, Seattle, Washington; Rik Wanninkhof, Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida*

2.6 Surface current observations – *Peter Niiler, Scripps Institution of Oceanography, California; Nikolai Maximenko, International Pacific Research Center, Honolulu, Hawaii*

2.7 Air-sea exchange of heat, fresh water, momentum – *Robert Weller, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts*

2.8 Sea ice extent and thickness – *Ignatius Rigor, University of Washington; Jackie Richter-Menge, Cold Regions Research and Engineering Laboratory*

Chapter 3: The State of the Observing System

There were many contributors to each FY 2004 progress report and FY 2005 planning report; please refer to authors identified in Chapter 3 under report titles.

Chapter 4: The State of the Science

Contributions were made by the authors of each bibliographic reference.

Reviewers

Michael Johnson and Masahiko Kamei, both of the NOAA Office of Climate Observation, reviewed all or part of this report. Their contributions are much appreciated. David Levinson, of the National Climatic Data Center, served as co-editor of the State of the Ocean component of the Executive Summary.

This report was made possible through the outstanding contributions of those listed above and throughout this report. It has been a pleasure to work with such motivated and committed individuals. Their vision, dedication, and ingenuity will enable advancement and completion of the global ocean observing system for climate.

APPENDIX F

List of Acronyms

List of Acronyms

| | |
|---------------|--|
| AAAS | American Association for the Advancement of Science |
| ABL | Atmospheric Boundary Layer |
| ADCP | Acoustic Doppler Current Profiler |
| AGU | American Geophysical Union |
| AMS | American Meteorological Society |
| AOML | Atlantic Oceanographic and Meteorological Laboratory |
| APDRC | Asia-Pacific Data Research Center |
| ARCs | Applied Research Centers |
| ARPEGE-CLIMAT | Climate Research Project on Small and Large Scales (France) |
| BAKOSURTANAL | National Coordinating Agency for Surveys and Mapping, Indonesia |
| BMRC | Bureau of Meteorology Research Centre (Australia) |
| BoM | Bureau of Meteorology (Australia) |
| BPR | Bottom Pressure Recorder |
| BSH | Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) (Germany) |
| CARINA | CARbon dioxide IN the Atlantic |
| C&GC | Climate and Global Change |
| CCHCO | CLIVAR and Carbon Hydrographic Data Office |
| CCRI | Climate Change Research Initiative |
| CCSP | Climate Change Science Program |
| CDC | Climate Diagnostics Center |
| CDIAC | Carbon Dioxide Information Analysis Center |
| CDP | Climate Data Portal |
| CEOF | Complex Empirical Orthogonal Function |
| CFD | Computer Flow Dynamics |
| CGPS | Continuously Operated GPS |
| CICOR | Cooperative Institute for Climate and Ocean Research |
| CIMAS | Cooperative Institute for Marine and Atmospheric Studies |
| CIRES | Cooperative Institute for Research in Environmental Sciences |
| CLIPS | Climate Information and Prediction Services Project |
| CLIVAR | CLimate VARIability and Predictability |
| C-MAN | Coastal-Marine Automated Network |
| COLA | Center for Ocean, Land, and Atmosphere Studies |
| COAPS | Center for Ocean-Atmospheric Prediction Studies |
| COOP | Coastal Ocean Observations Panel (GOOS) |
| COP | Climate Observation Program |
| CORC | Consortium on the Ocean's Role in Climate |
| COSC | Climate Observing System Council |
| COSP | Climate Observations and Services |
| CLIVAR | Climate Variability and Predictability Program |
| CPC | Climate Prediction Center |
| CPRDB | Comprehensive Pacific Raining Database |
| CSIRO | Commonwealth Scientific and Industrial Research Organization |
| CTD | Conductivity, Temperature, Depth |
| DAC | Data Assembly Center |
| DART | Deep Ocean Assessment and Reporting of Tsunamis (Buoy) |
| DBCP | Data Buoy Cooperation Panel |
| DCP | Data Collection Platform |
| DCS | Data Collection System |

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| DMC | Drought Monitoring Center |
| DODS | Distributed Ocean Data System |
| DOE | Department of Energy |
| DSL | Digital Subscriber Line |
| DWBC | Deep Western Boundary Current |
| ECCO | Estimating the Circulation and Climate of the Ocean |
| ECMWF | European Centre for Medium-Range Weather Forecasts |
| ENSO | El Niño-Southern Oscillation |
| EOF | Empirical Orthogonal Function |
| EPIC | Eastern Pacific Investigation of Climate |
| ERS | Earth Remote-sensing Satellite |
| ETL | Environmental Technology Laboratory |
| EVAC | Environmental Verification and Analysis Center |
| FAO | Food and Agriculture Organization (UN) |
| FGDC | Federal Geographic Data Committee |
| FRX | Frequently Repeated XBT |
| FSU-COAPS | Florida State University Center for Ocean-Atmosphere Prediction Studies |
| GAINS | GLOSS Development in the Atlantic and Indian Oceans |
| GCC | Global Carbon Cycle |
| GCOS | Global Climate Observing System |
| GCP | Global Carbon Project |
| GCTE | Global Change and Terrestrial Ecology Program |
| GCRMN | Global Coral Reef Monitoring Network |
| GDC | Global Drifter Center |
| GDP | Global Drifter Program |
| GEOSAT | Geodesy Satellite |
| GIS | Geographic Information System |
| GLOSS | Global Sea Level Observing System |
| GODAE | Global Ocean Data Assimilation Experiment |
| GOES | Geostationary Operational Environmental Satellite |
| GOOS | Global Ocean Observing System |
| GPCP | Global Precipitation Climatology Project |
| GPS | Global Positioning System |
| GPS@TG | Co-located GPS systems at tide gauge stations |
| GSOP | Global Synthesis and Observations Panel of CLIVAR |
| GTS | Global Telecommunications System |
| GTSP | Global Temperature-Salinity Profile Program |
| HRX | High Resolution XBT |
| HURDAT | Atlantic Basin Hurricane Database |
| IAI | Inter-American Institute for Global Change Research |
| IOC | Intergovernmental Oceanographic Commission |
| IDOE | International Decade of Ocean Exploration |
| IES | Inverted Echo Sounder |
| IFREMER | Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea) (France) |
| IGBP | International Geosphere-Biosphere Programme |
| IGCO | Integrated Global Carbon Observing team |
| IHO | International Hydrographic Organization |
| IMBER | Integrated Marine Biogeochemistry and Ecosystem Research |
| IMET | Improved METeorological Instrument |
| IOCCP | International Ocean Carbon Coordination Project |

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| IOOS | Integrated Ocean Observing System |
| IOOS-DMAC | Integrated Ocean Observing System – Data Management and Communication |
| IPRC | International Pacific Research Center |
| IRD-Brest | L’Institut de recherché pour le developpement – Brest (France) |
| IRI | International Research Institute for Climate Prediction |
| ITCZ | Inter-Tropical Convergence Zone |
| IUGG | International Union of Geodesy and Geophysics |
| JAMSTEC | Japan Agency for Marine-Earth Science and Technology |
| JASL | Joint Archive for Sea Level |
| JCOMM | Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology |
| JGOFS | Joint Global Ocean Flux Survey |
| JIMAR | Joint Institute for Marine and Atmospheric Research, University of Hawaii |
| JIMO | Joint Institute for Marine Observations |
| JISAO | Joint Institute for the Study of the Atmosphere and Ocean |
| JMA | Japan Meteorological Agency |
| J-OFURO | Japanese Ocean Flux data sets with Use of Remote sensing Observations |
| JPL | Jet Propulsion Laboratory |
| JTA | Joint Tariff Agreement |
| KE | Kuroshio Extension |
| KEO | Kuroshio Extension Observatory |
| KESS | Kuroshio Extension System Study |
| LAS | Live Access Server |
| LLNL | Lawrence Livermore National Laboratory |
| MAN | Management Committee (JCOMM) |
| MEDS | Marine Environmental Data Services |
| MJO | Madden-Julian Oscillation |
| MOC | Meridional Overturning Circulation |
| MOCHA | Meridional Overturning, Circulation and Heat Transport Array |
| MOU | Memorandum of Understanding |
| NACP | North American Carbon Program |
| NAO | North Atlantic Oscillation |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research |
| ncBrowse | Graphical netCDF File Browser |
| NDBC | National Data Buoy Center |
| NCDC | National Climatic Data Center |
| NCDDC | National Coastal Data Development Center |
| NCEP | National Centers for Environmental Prediction |
| NEAR-GOOS | North-East Asian Regional GOOS |
| NERC | National Environmental Research Council |
| NESDIS | National Environmental Satellite, Data, & Information Service |
| netCDF | network Common Data Form |
| NGO | Non-Governmental Organization |
| NIC | National Ice Center |
| NIH | National Institutes of Health |
| NIWA | National Institute of Water and Atmospheric Research (New Zealand) |
| NMFS | National Marine Fisheries Service |
| NMHS | National Meteorological and Hydrological Services |
| NMRI | Naval Medical Research Institute |
| NOAA | National Oceanic and Atmospheric Administration |

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| NODC | National Oceanographic Data Center |
| NOPP | National Ocean Partnership Program |
| NORPAX | North Pacific Experiment |
| NOS | NOAA Ocean Service |
| NOSA | NOAA Observing System Architecture |
| NRC | National Research Council |
| NSCAT | NASA Scatterometer |
| NSF | National Science Foundation |
| NTC | National Tidal Centre, Australia |
| NWP | Numerical Weather Prediction |
| NWS | National Weather Service |
| NWS-PR | National Weather Service Pacific Region |
| NVODS | National Virtual Ocean Data System |
| MON | NWS Marine Observation Network |
| OCCE | Ocean Carbon and Climate Change Program |
| OceanSITES | Ocean Sustained Interdisciplinary Time series Environmental Observatory |
| OCO | Office of Climate Observation |
| ODINAFRICA | Ocean Data and Information Network for Africa |
| OGP | Office of Global Programs |
| OMAO | Office of Marine and Aviation Operations |
| OOPC | Ocean Observations Panel for Climate |
| OpenDAP | Open Source Project for Network Data Access Protocol |
| PacificGOOS | Pacific Global Ocean Observing System |
| PACIS | Pan-American Climate Information System |
| PDO | Pacific Decadal Oscillation |
| PEAC | Pacific ENSO Applications Center |
| PHOD | Physical Oceanography Division |
| PIES | Pressure Gauge Equipped Inverted Echo Sounder |
| PMEL | Pacific Marine Environmental Laboratory |
| PNA | Pacific North America |
| PNNL | Pacific Northwest National Laboratory |
| POGO | Partnership for the Observation of the Global Oceans |
| QSCAT | Seawinds on QuikScat |
| RRP | ENSO Rapid Response Project |
| RSMAS | Rosenstiel School of Marine and Atmospheric Science |
| RVIB | Research Vessel / Ice Breaker |
| RVSMDC | Research Vessel Surface Meteorology Data Center |
| SAC | Special Analysis Center |
| SAR | Synthetic Aperture Radar |
| SCPP | Seasonal-to-Interannual Climate Prediction Program |
| SCMI | Southern California Marine Institute |
| SCOR | Scientific Committee for Ocean Research |
| SEACOOS | Southeast Atlantic Coastal Ocean Observing System |
| SEAFLUX | Ocean Surface Turbulent Flux Project |
| SEARCH | Study of Environmental Arctic Change |
| SEAS | Shipboard Environmental data Acquisition System |
| SEC | South Equatorial Current |
| SI | Seasonal-to-Interannual |
| SIO | Scripps Institution of Oceanography |
| SIO-ECPC | Scripps Institution of Oceanography-Experimental Climate Prediction Center |
| SLP | Sea Level Pressure |

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| SLP-PAC | Sea Level Program in the Pacific |
| SOC | Southampton Oceanography Centre |
| SOI | Survey of India |
| SOLAS | Surface Ocean-Lower Atmosphere Study |
| SOOP | Ship-of-Opportunity Program |
| SOOPIP | Ship-of-Opportunity Implementation Panel |
| SOI | Southern Oscillation Index |
| SOT | Ship Observations Team |
| SPARCE | South Pacific Rainfall Climate Experiment |
| SPCZ | South Pacific Convergence Zone |
| SRDC | Surface Reference Data Center |
| SSG | Scientific Steering Group |
| SSP | Sea Surface Pressure |
| SST | Sea Surface Temperature |
| START | Global Change System for Analysis, Research, and Training |
| SURFRAD | Surface Radiation Budget Network |
| TAO | Tropical Atmosphere Ocean Array |
| TMI | TRMM Microwave Imager |
| TOGA | Tropical Oceans-Global Atmosphere Program |
| TOPEX | Ocean TOPography Experiment |
| TRMM | Tropical Rainfall Measurement Mission |
| UHSLC | University of Hawaii Sea Level Center |
| UNCED | United Nations Conference on Environment and Development |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UOTC | Upper Ocean Thermal Center |
| URI | University of Rhode Island |
| USIABP | U.S. Interagency Arctic Buoy Program |
| USGCRP | U.S. Global Change Research Program |
| UW | University of Washington |
| VOS | Voluntary Observing Ships |
| WCRP | World Climate Research Program |
| WDC-A | World Data Center-A for Oceanography |
| WHO | World Health Organization |
| WHOI | Wood's Hole Oceanographic Institution |
| WMO | World Meteorological Organization |
| WOCE | World Ocean Circulation Experiment |
| WWE | Westerly Wind Event |
| WWW | The World Weather Watch of WMO |
| XBT | Expendable Bathythermograph |
| XCTD | Expendable Conductivity Temperature Depth |